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This list was prepared before the recent dispute in the printing industry which has greatly delayed publication. We regret that recent staff changes are not, therefore, included.

Some Problems of Jute Cultivation on the Coastland Soils of British Guiana

By G. D. Baxter

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INTRODUCTION

The main soil types of the coastlands in British Guiana are:

(1) *Frontland Clay:* Originally this type was probably covered by swamp and marsh vegetation and has been developed over non-calcareous marine alluvium saturated with sea-water. The surface layers have been drained since the land was brought under cultivation to sugar-cane and rice. On lands under standing cultivation the salts have been completely leached out from the surface soil, the process having been accelerated by "flood fallowing" on the sugar estates. This top soil is on the whole highly acid, about pH 4·7, but acidity disappears below 12 inches. The phosphate status is low, the Truog values for available phosphate often being below the critical level (17 p.p.m.) adopted by the British Guiana Department of Agriculture for sugar-cane. The values for available potash vary from about 125 to 250 p.p.m.[1] which can be regarded as medium, as values over 200 p.p.m. are considered adequate for sugar-cane. Nitrification is tardy, with exchangeable ammonium plentiful in some places[2]. Organic matter content ranges from 5 to 2 per cent., and low carbon-nitrogen ratios are sometimes encountered even on the surface where the ratio is usually about 10.

Although the salt has been leached from the top soil the subsoil water still has the same composition as diluted sea water[3]. It is common to find large quantities of exchangeable magnesium in the subsoil, this accounting on the average for between 50 and 75 per cent. of the total exchangeable bases. High exchangeable sodium is also not uncommon, while exchangeable calcium can be extremely low.

This soil is inherently poorly aggregated, and suffers from water-logging, although it forms the bulk of cultivated land in the colony, the crops being mainly sugar-cane and rice.

(2) *Pegassy Clay and Pegasse:* These were originally occupied by arboraceous fresh water swamp vegetation, and are typical "tropical peat soils". They merge below into bleached white "buttery" clay. These soils are highly acid, and acidity increases with depth, except where the subsoil is saline. The organic matter content may reach over 80 per cent., with phosphate status extremely low (less than 20 p.p.m.) and potash medium though variable (125-250 p.p.m.). Exchangeable aluminium (extractable by 0·5 N acetic acid) rises with increasing acidity reaching toxic levels by pH 4·7[4]. This critical value is however dependent on the amount of phosphate or sulphate present[5]. In most cases the amount of exchangeable aluminium present is capable of being

toxic to certain crop plants. Invariably also, the sulphate content is high.

The greater part of these soils is still underdrained and uncultivated. Where the organic matter and exchangeable aluminium content are not too high, sugar-cane or rice is grown.

(3) *Riverside Silt:* This comprises levees covered with swamp and marsh forest. Drainage and leaching have converted it into podsolic types. Sand content may be high, and the soil is highly acid, the acidity increasing with depth. Organic status is low and both phosphate and potash very low.

(4) *Reef Sand:* This comprises low bands and dunes occurring in patches in the frontland clays. The sand is of medium to coarse grade. This soil type is generally cultivated to coconuts or used for housing.

Hardy and Rodrigues[1] in their study of typical sugar-cane soil profiles summarized the common features of the cultivated layer as:

"(1) Very high acidity.
(2) Medium to high total nitrogen.
(3) Medium to low carbon-nitrogen ratios, except for pure pegasse.
(4) Harmless amounts of salt.
(5) Very low available phosphate contents.
(6) Variable, though mostly inadequate, available potash contents.
(7) Variable degree of water-logging."

Jute is derived from the two species *Corchorus capsularis* L. and *C. olitorius* L. of the family Tiliaceae. Both species have been grown in India for several centuries, but while *C. olitorius* would appear to be indigenous to India, *C. capsularis* was almost certainly introduced—possibly from China. The crop tends to be associated with India, and in fact half the jute of commerce is grown on a rather narrow strip of country on both sides of the Brahmaputra in East Bengal[6]. The remainder is mostly grown in the Ganges Delta. Although efforts have been made for some time to grow jute on a commercial scale in countries outside Asia, it is exacting regarding its environment and only in Amazonia has cultivation shown any real success.

From this emerges the significant fact that, between India and Amazonia, one of the common keys to success is the fact that in both countries the crop is grown almost entirely on alluvial deposits. Two others are climate and plentiful peasant labour.

The soils on which jute is produced in India are, as stated, almost entirely alluvial and fall into three groups, the two important types being:

(1) *The Brahmaputra alluvium*, a greyish soil with little or no carbonate of lime, well supplied with potash and containing satisfactory amounts of phosphoric acid. Both mineral and organic matter are replenished annually by flood deposit, and the only recommended addition has been potash.

(2) *The old red alluvium*, of which there is a large area in Bengal and Assam, is definitely acid, deficient in phosphoric acid and more moderately so in available potash. Jute cultivation tends to be less dense in this area,

and recommended additions are lime, cow-dung, bone-meal and muriate of potash.

It is reported[7] that the crop thrives best on rich, loamy or alluvial soil with good drainage and adequate provision for soil aeration. Clay or clay-silicose soils with an appreciable deposit of organic material are suitable in that they offer a good balance of physico-chemical conditions. Heavy clay, however, and sandy or alkaline soils are regarded as unsuitable[8]. Certain parts of Bengal are recognised as poor jute producers because of the rather heavy soils prevailing in those areas[9,10]. The physical condition of such soils is improved by the application of cow-dung[11].

In Brazil, jute is mostly grown on the low flood lands of the Amazon Valley in fields located on the alluvial overflow banks of the river. Shifting cultivation is operated on a 2 to 4 year basis and the soil fertility is restored by an alluvial deposit consisting of clayey colloids, particles of fine sand and clay, humic acids in solution and vegetable organic matter in suspension[8].

CULTIVATION ON FRONTLAND CLAY

Jute was cultivated on frontland clay at Enterprise Estate, Canje, Berbice. The land was laid out on the sugar estate "English" system in which the fields are intersected by drains running from the high level irrigation canal (middlewalk) to the low level drainage canal (sideline), and are made up into a series of cambered beds approximately 25 feet wide. The field drains serve for both irrigation and drainage. Tillage, which was fully mechanized, was also based on the sugar estate system.

On this soil the crop could be grown to a satisfactory if variable height, although the yields fell considerably below expectation. One of the main reasons for this was a progressive deterioration in both stand and plant height from the centre of the bed to the drain edge. This effect results directly from the methods of mechanical tillage.

An integral part of large-scale tillage in British Guiana is the use of the Cuthbertson drain digger for digging or cleaning the interbed drains. This machine pulls a drain with a $2\frac{1}{2}$ feet top, 1 foot bottom and 3 feet depth from the top of the bed camber. The spoil is spread over 6 feet of bed on both sides of the drain. The soil on any particular field bed can, therefore, be divided into two classes, viz.:

(1) *Pure topsoil*—topsoil which has been mixed to the maximum cultivation depth, normally not more than 12 inches. The chemical properties of the soil (high acidity, low phosphate and tardy nitrification), although basically unsuitable for jute requirements, can be overcome by manurial addition and the following fertilizer recommendations have been found, in general, satisfactory:

Nitrogen: 30 lb. N per acre per crop applied as 21 per cent. sulphate of ammonia in two separate top dressings each of 15 lb. N.

Phosphate: 30 lb. P_2O_5 per acre per crop applied as 45 per cent. granular triple superphosphate harrowed into the final seedbed.

Potash: 27 lb. K_2O as muriate of potash per acre every 2 to 3 years harrowed into the seedbed.

Limestone: 1 ton per acre ploughed in as often as deemed necessary. The physical properties, however, are such that during the early part of the growing season the plants suffer through prevention of proper soil aeration, even where obvious water-logging is avoided by adequate field drainage. Good jute cultivation is synonymous with a well aggregated soil, and the frontland clays are poorly aggregated for two reasons:

(a) relatively high magnesium content leading to clay dispersion.
(b) medium to low organic matter status.

The importance of this is reflected in a series of measurements taken on *C. capsularis*:

	Site-type A	Site-type B
Mean height (55 measurements)	6·05 feet	4·48 feet

An increase of 35 per cent. from B to A.

The soil at A (0-6 inches), when crumbled and pressed firmly in the hand, could be crumbled again; whereas the soil at B (0-6 inches) could either not be crumbled, or, when pressed, not crumbled a second time. The sites were never more than 6 feet apart and the soil was identical apart from (a) *vertical* drainage (b) aggregation. Under conditions of poor *lateral* drainage differences of up to 70 per cent. have been recorded.

Such soil can be considerably improved by the addition of organic matter. 37 sites were chosen where wood (pith) fragments and leaves had been deposited by ribboners at harvest, and worked in to a depth of 6 inches by disc harrow. The jute on these sites showed a 41·7 per cent. increase in height over adjacent sites.

(2) *Drainside soil* (hereafter referred to as mixed soil) where the Cuthbertson drain digger has deposited subsoil on the bed, and this has become mixed with the topsoil by harrowing. This type occupies no less than 35-50 per cent. of the total effective acreage (acreage which excluded inter-bed drains).

It was found that jute established badly on the mixed soil, leading to a thin stand, and individual plant height was in general less than in the centre of the bed. The leaves were often yellow-green in colour through nitrogen deficiency, indicating a wastage of the applied sulphate of ammonia. Measurements showed that the ratio of yield on mixed soil to yield on pure topsoil was 45·6 per cent., and the overall reduction of potential yield was 32·6 per cent. In the extreme case, as experienced on deep sand and pegassy clay, the few plants which established on the mixed soil did not exceed 6 inches in height and the result was complete failure (Plate I).

The basic factors leading to this effect are:

(a) High magnesium content.
(b) Relatively low carbon : nitrogen ratios (Mean for 0-10 inches).
(c) High ferrous iron and medium exchangeable aluminium content.

(a) and (b) react together to give anaerobic conditions which in turn

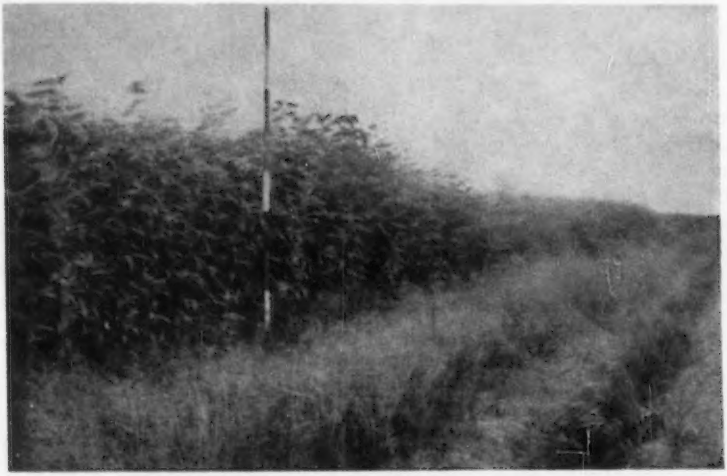


PLATE I. Complete failure of *C. capsularis* on "mixed soil" as shown between the ranging pole and the drain in right foreground

[facing page 76

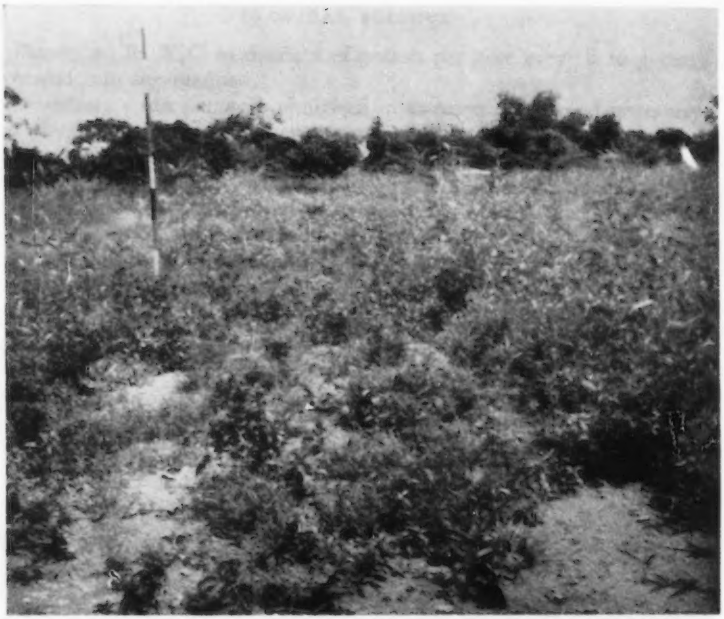


PLATE II. Failure of *C. olitorius* on pegassy clay showing bare ground in foreground and patchiness of the weed flora

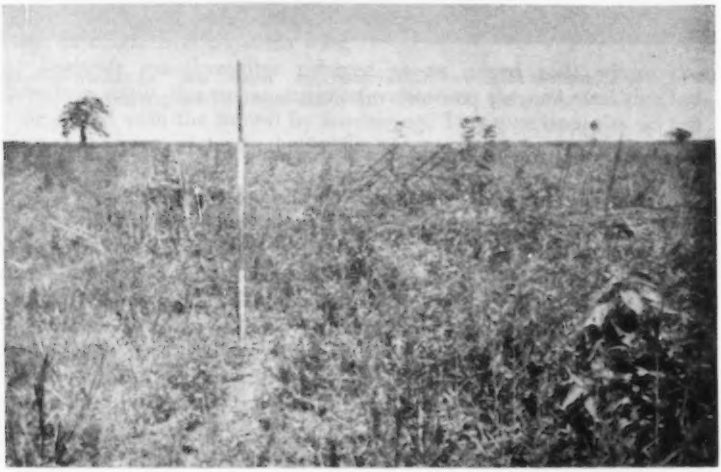
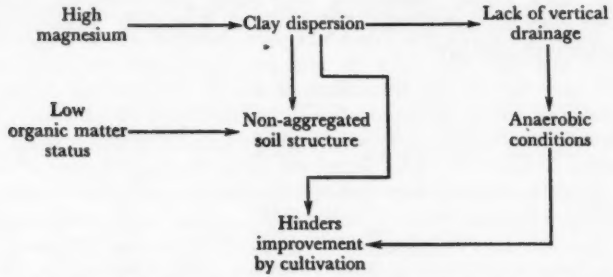


PLATE III. Failure of *C. olitorius* on pegassy clay of lower aluminium content than that in Plate II. This soil supports a greater variation of weed flora including grass species

facing page 77]

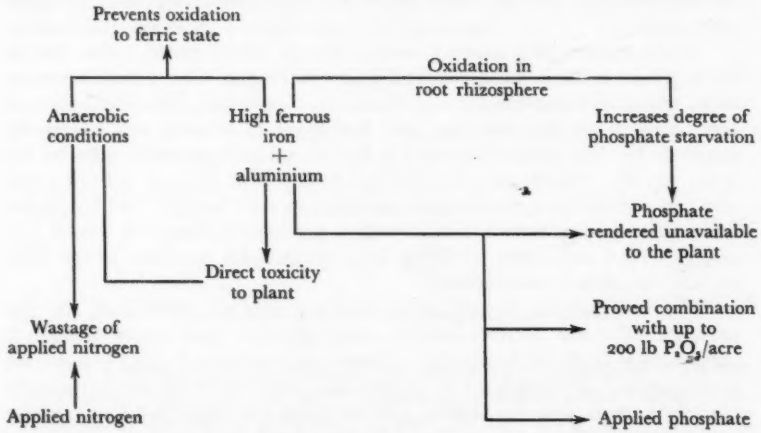
react with (c) to cause phosphate and nitrogen starvation. (Figures I and II).

FIG. I



Even a superficial examination of mixed soil during the early part of the growing season will show the presence of a perched water table with complete lack of vertical drainage and consequent anaerobic conditions. While crops such as rice or sugar-cane are tolerant of such conditions the young jute plant is unable to withstand *any* degree of water-logging, although the mature plant of *C. capsularis* can grow in water 6 feet deep.

FIG. II


Prevents oxidation to ferric state
Oxidation in root rhizosphere
Anaerobic conditions
High ferrous iron + aluminium
Increases degree of phosphate starvation
Phosphate rendered unavailable to the plant
Direct toxicity to plant
Proved combination with up to 200 lb P_2O_5/acre
Wastage of applied nitrogen
Applied nitrogen
Applied phosphate

Bourne[12] has shown that the phosphate fixing capacity of such soils is very high and that there is a lack of response to phosphate manuring. In the case of jute, application of up to 200 lb. of P_2O_5 per acre caused no improvement either in the stand or growth rate of young jute. The problem of nitrification in the sugar-cane soils of British Guiana is complex [13, 2] and therefore, without careful study, little comment can be made on the problem of nitrogen starvation. It would appear however that at any particular level of manurial application a certain proportion of the nitrogen is rendered unavailable to the plant.

CULTIVATION ON PEGASSY CLAY

Jute was first planted on pegassy clay in 1957 at the Central Agricultural Station, East Coast, Demerara. The result was complete failure of *Corchorus olitorius* and partial failure of *C. capsularis*. Typical analysis figures for such soils are:

TABLE I

Location	K_2O p.p.m.	Al_2O_3 p.p.m.	Available P_2O_5 p.p.m.	Fe p.p.m.
Bed centre . . .	113	2,079	28	11·1
" " . . .	289	3,024	18	13·3
" " . . .	147	2,797	19	35·7
" " . . .	113	926	44	7·5
Bed edge . . .	106	491	19	15·4
" " . . .	121	832	5	33·3
" " . . .	94	718	14	17·2
" " . . .	166	1,663	9	100·1

The *olitorius* jute showed extremely poor germination and the majority of plants did not reach 6 inches in height, although occasional plants went on to reach 3 to 5 feet in height (Plates II and III). The roots were either rotted or severely stunted with abundant formation of lateral roots to replace the normal deep taproot. There were no leaf or other abnormalities.

The *capsularis* jute showed comparatively better germination and in some places a thick stand reached 6 feet in height. There were however large areas of complete failure similar to *C. olitorius*. The roots showed less necrosis but the stunting and formation of laterals was extremely marked. In some areas there was a distinct chemotropic response by the main tap root, which at a depth of 3-6 inches bent through a right angle and ran parallel to the surface. In addition to the "bushy" root formation there were groups of very short swollen rootlets—a symptom which was also observed on cotton suffering from aluminium toxicity. There were no leaf or other abnormalities.

The conclusions drawn from detailed analysis were that, in the presence of a low ferrous iron content, *capsularis* jute could tolerate a surprisingly high exchangeable aluminium content (6 feet height on 3,000 p.p.m.), although for a commercial yield the level was tentatively placed at 500 p.p.m. For *olitorius* jute the level was somewhat lower, being in the region of 300 p.p.m. The tolerance limit for iron *in the presence of free aluminium* was, for a commercial yield, placed at 20 p.p.m. in the case of *capsularis* jute, and 15 p.p.m. in the case of *olitorius* jute. As high iron was in no case associated with less than 700 p.p.m. aluminium it was impossible to determine the lowest level of aluminium at which the iron toxicity would manifest itself.

It was therefore decided to apply limestone, to suppress high aluminium-iron concentration and release phosphate fixed by hydrous ferric oxide and alumina. Ground limestone was applied as a top dressing to the autumn crop 1957, broadcast and ploughed in for the spring crop

1958, and again broadcast and ploughed into experimental plots for the autumn crop 1958. By then all land had received either 2, 3 or 4 tons per acre and the experimental plots 8-12 tons per acre. The land was cropped with cowpeas (*Vigna sinensis*) for the spring crop 1958, and sown to jute again for the autumn crop. The result was a repetition of the 1957 failure with no significant response to even the heaviest limestone application. Soil analysis figures were virtually unchanged from the 1957 survey and showed the presence of large quantities of free limestone.

These results are in agreement with the work of Williams and Follett-Smith[14], who have shown that the liming of British Guiana sugar-cane soils fails to "elicit a sure response." Hardy and Rodrigues[1] suggest that one possible reason is lack of carbonation, with the applied limestone not being brought into solution. Also, "there might be a tardiness in the rate of oxidation of plant residues owing to lack of aeration, or to a reducing potential or an unsuitable micro-organic flora."

CULTIVATION ON DEEP SAND (I)

Deep sand is a composite soil type with a subsoil of sand and a sandy clay or silty clay surface. The occurrence of this type is restricted and probably represents the point where the reef sand disappears below the clay or silty clay on either side. The overlying clay has some of the properties of frontland clay, while the sand may have a high soluble salt and available aluminium content. Typical analysis figures are:

TABLE II

Location*	K_2O p.p.m.	Al_2O_3 p.p.m.	Available P_2O_5 p.p.m.	Fe p.p.m.
Bed centre . . .	121	1,833	33	143·0
,, ,, . . .	137	1,928	29	71·4
Bed edge . . .	128	1,380	13	143·0
,, ,, . . .	188	2,041	20	125·0

* Central Agricultural Station, East Coast, Demarara.

The growth of jute on this soil type was strictly comparable with that on pegassy clay, and the same manurial additions were carried out. *C. capsularis* showed a difference in that the first crop, which followed the ploughing-in of standing sugar-cane, was slightly better than on pegassy clay, but the second crop was a more marked failure. This suggested a possible correlation between iron toxicity and organic matter content which was later verified (Deep Sand II below).

In this area there was a small bed of shell reef with the analysis figures:

TABLE III

Al_2O_3 p.p.m.	Available P_2O_5 p.p.m.	Fe p.p.m.
227	78	9·0

This soil grew *olitorius* jute with a yield of 1,452 lb. dry fibre per acre, in contrast to the surrounding deep sand with a yield of 420 lb. dry fibre per acre (Plate IV.) Both the aluminium and iron content of the shell reef fell within the toxicity limits given above, and with the lower rate of fixation the phosphate status rose from 28 p.p.m. to 78 p.p.m.

CULTIVATION ON DEEP SAND (II)

This land was adjacent to frontland clay and was classified as such until it was discovered, through the failure of a jute crop, that the clay was in fact overlying a sand reef. Analysis figures for this type of soil are:

TABLE IV

Location*	pH	K_2O p.p.m.	Al_2O_3 p.p.m.	Available P_2O_5 p.p.m.	Fe p.p.m.
Bed centre . .	4·8	90	136	14·0	38·5
,, ,, . .	4·7	105	121	13·0	37·0
,, ,, . .	4·6	95	151	5·0*	83·3
,, ,, . .	4·9	110	166	5·0*	62·5
,, ,, . .	4·3	105	219	8·0	60·6
,, ,, . .	4·8	95	219	11·0	55·6

* Central Agricultural Station, East Coast, Demerara.

The land, which had been under sugar-cane was sown with jute for the autumn crop 1958. The *olitorius* jute showed bad germination, reminiscent of the failure on deep sand (I) and pegassy clay, and in spite of seed supplying, the stand remained thin and gappy. The plants grew to 3-4 feet in height where they remained for 4 to 6 weeks, before showing a final period of increased growth rate, during which they reached 6 feet. The average yield per acre was 238 lb. dry fibre. The *capsularis* jute showed excellent germination and grew rapidly to a height of 3-4 feet, with patches up to 6 feet. Then growth virtually ceased, the leaves became yellow-green in colour in spite of extra nitrogenous top dressing, and, by maturity, the overall height was only 6 feet. The average yield per acre was 390 lb. dry fibre. The roots of both species showed the symptoms:

(a) slight necrosis of rootlets and more especially rootlet tips, from which it could be inferred that the level of available aluminium was toxic *per se*, but not significantly so.

PLATE IV. *C. olitorius* showing stunted growth on deep sand in the foreground, and good growth on shell reef behind the ranging pole in the background

[*facing page* 80

(b) an increased yellowing of the root tip which was shown by laboratory experiment to be caused by high iron content.

The field symptoms were repeated in the laboratory applying 50 p.p.m. ferric citrate + 200 p.p.m. aluminium sulphate to jute growing in aggregate culture; and it was concluded that the crop failure was caused by soil toxicity through high iron content in the presence of medium-low aluminium content.

The problem was complicated by a correlation between toxicity, soil physical conditions and organic matter status. This meant, for example, that *olitorius* jute reached a height of 7 feet (895 lb. dry fibre per acre) on

$$98 \text{ p.p.m. } Al_2O_3 + 83{\cdot}3 \text{ p.p.m. Fe}$$

after sowing on ploughed-in grassland (*Brachiaria purpurascens*): but failed even to establish on

$$98 \text{ p.p.m. } Al_2O_3 + 50{\cdot}0 \text{ p.p.m. Fe}$$

in the adjacent field which possessed poor physical conditions.

TABLE V

Records for *C. olitorius*

	Height	Al_2O_3 p.p.m.	Fe p.p.m.
(1) Good physical conditions, high organic matter status*	10′ 0″	121	28·0
	7′ 6″	68	43·5
	7′ 0″	98	83·3
(2) Poor physical conditions, low organic matter status	4′ 6″	53	20·2
	4′ 0″	106	24·5
	failure	68	12·6

* Occurs over not more than 10% of the total effective acreage.

The following limits of tolerance were drawn up for:

C. capsularis

(1) Good physical conditions

up to 100 p.p.m. Fe at less than 150 p.p.m. Al_2O_3

„ 15 p.p.m. Fe „ „ 400-500 p.p.m. Al_2O_3

(2) Bad physical conditions

up to 20 p.p.m. Fe at less than 100 p.p.m. Al_2O_3

C. olitorius

(1) Good physical conditions

up to 100 p.p.m. Fe at less than 100 p.p.m. Al_2O_3

„ 15 p.p.m. „ „ „ 300 p.p.m. Al_2O_3

(2) Bad physical conditions

up to 15 p.p.m. Fe at less than 50 p.p.m. Al_2O_3

There is therefore every indication that, in spite of its comparatively high tolerance of aluminium toxicity, *capsularis* jute is almost as sensitive as *olitorius* to iron toxicity (in the presence of aluminium).

MODE OF TOXICITY

As yet, the mode of action of available aluminium and iron on the jute plant has not been studied in detail. It is known that aluminium causes necrosis either at the tip of the root, or immediately behind the meristematic region, causing actual destruction of the rooting system. The difference in tolerance shown by *capsularis* and *olitorius* jute can be explained on a simple basis of seed reserve in relation to seedling root destruction. The *olitorius* seed with its extremely small seed reserve can only withstand the destruction of a limited number of roots, and therefore will fail to establish at a high level of available aluminium. Even where the level is such as to permit establishment, the *olitorius* plant will always be at a disadvantage to the *capsularis* plant which may have 2 to 3 times as effective a root system. The "bushy" roots shown by *capsularis* jute are an indication of its potential for replacing destroyed rootlets.

Ferrous iron is reported to be directly toxic to plants under anaerobic conditions, but its chief mode of action is undoubtedly through rendering phosphate unavailable to the plant. It would seem reasonable to assume that a plant whose rooting system is reduced in size and efficiency by any level of aluminium toxicity, can no longer cope with the additional problem of phosphate starvation through the presence of ferrous iron.

USE OF DATA

The experience and data gained from the work discussed above has now made it possible to accurately interpret, in terms of expected yield, the soil analysis data from any area under consideration for jute cultivation. Table VI shows the analysis data from 16 samples taken at Non Pareil, East Coast, Demerara (Enmore Sugar Estates Ltd.).

TABLE VI

Location	Depth in inches	pH	Total Soluble Salts *per cent.*	Organic Matter *per cent.*	Available P_2O_5 p.p.m.	Exchangeable Bases—p.p.m.						
						Fe	Al	Mn	Ca	Mg	Na	K
Bed												
A edge	0–6	4·54	0·083	2·438	13	360	7	56	430	1180	270	190
,,	6–12	4·65	0·098	2·289	11	86	82	35	440	1230	340	190
centre	0–6	4·72	0·041	2·438	8	760	130	67	540	1450	190	310
,,	6–12	4·74	0·038	1·989	8	97	9	44	430	1190	240	230
B ,,	0–6	4·56	0·032	1·589	10	230	40	50	590	1320	330	260
edge	0–6	5·23	0·038	1·791	8	765	51	67	540	1370	300	280
C centre	0–6	5·86	0·044	1·791	19	260	66	75	650	1410	330	280
edge	0–6	6·11	0·033	1·745	17	975	60	143	660	1440	260	400
D centre	0–12	6·48	0·046	1·498	25	210	180	192	710	1510	370	400
edge	0–6	5·34	0·035	1·890	12	830	100	179	560	1300	350	360
E centre	0–6	4·75	0·054	2·181	11	77	20	45	670	1290	280	220
,,	6–12	4·76	0·098	2·388	18	39	66	45	590	1290	390	200
edge	0–6	5·16	0·083	1·989	15	27	51	45	620	1460	380	160
,,	6–12	4·94	0·164	2·238	15	45	84	26	550	1250	4900	180
F centre	0–6	4·94	0·040	2·022	13	55	55	43	540	1320	190	350
edge	0–6	4·89	0·031	2·022	14	33	46	45	580	1460	200	180

The available land fell into three groups:

1. Site A: Flood-fallowed, with no cultivation immediately prior to fallowing, and drained before samples were taken.
2. Sites B, C, D: Flood-fallowed and ploughed before flooding. Under water at the time of sampling.
3. Sites E, F: Under 4th ratoon sugar-cane.

The land under 4th ratoon cane had visibly poor structure while that at A showed the improved structure expected after flood fallowing. Overall outstanding features of the area were:

(a) very low organic matter content, even for frontland clays;
(b) iron content tends to remain high even after 5 years under cane;
(c) available phosphate status very low;
(d) potash status medium to good.
(e) manganese content satisfactory;
(f) calcium : magnesium ratio bad.

The probable crop reaction was judged to be:

Sites E, F: 4th ratoon cane soil

This soil would not be toxic although the figures of 6-12 inches were slightly above the tolerance level for *olitorius* jute to high iron in the presence of aluminium. There would be a definite lowering of yield on the "mixed soil" (verified by a pot experiment at 45·7 per cent. of the pure top soil), and the overall physical properties would restrict the yield to not more than one-third of a ton of fibre per acre.

Sites B, C: Flood-fallowed soil

With its friable structure this soil would give a satisfactory first crop, with yields in the region of one-half to three-quarters of a ton of fibre per acre. However, with the high magnesium and sodium content coupled with low organic matter and calcium, the soil would be expected to show very rapid deterioration to the state observed under the 4th ratoon cane.

Sites A and D: Flood-fallowed soil

This soil would be toxic by virtue of high iron in the presence of low aluminium, and the variability shown by the aluminium figures would point to the possibility of sites such as A and D occurring at random within the area.

In general, therefore, an area such as that sampled, while satisfactory for the cultivation of sugar-cane, rice or ground provisions, could not be recommended for jute.

SUMMARY

1. The general properties of the coastland soils in British Guiana are listed and compared with those of soils in India and Brazil known to be suitable for jute cultivation.

2. Consideration is given to the reaction of jute to the chemical and physical properties of frontland clay.
3. The history of jute cultivation on:
   (i) Pegassy clay
   (ii) Deep Sand (I)
   (iii) Deep Sand (II)
   is discussed with special reference to soil toxicity by exchangeable aluminium and ferrous iron.
4. An example is given of the interpretation of soil analysis data from an area under consideration for jute cultivation.

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References

(1) Hardy, F. and Rodrigues, G. "Some Sugar-cane Soil Profiles of British Guiana". Proceedings of the 1946 Meeting of *British West Indies Sugar Technologists*, Antigua, B.W.I., 1946.
(2) Hardy, F. and Rodrigues, G. "The Nitrogen Enigma of the Sugar-cane Soils of British Guiana". *Paper No.* 8a/51, *Imp. Coll. Trop. Agric., Trinidad*, 1951.
(3) *Report, Chemistry Division, Department of Agriculture, British Guiana*, 1931, 74.
(4) Magistad, O. C. "The Aluminium content of Soil Solution and its Relationship to Soil Reaction and Plant Growth". *Soil Science*, 1925, **29**, 181.
(5) McLean, Joffe. *Ann. Report Soils Division New Jersey Agric. Expt. Sta.*, 1927, 333.
(6) Haarer, A. E. "Jute Substitute Fibres", London: Wheatland Journals Ltd., 1952.
(7) Howard, A. "Crop Production in India", London Oxford Univ. Press, 1942.
(8) Thury, Admar. "A Jute Brasileira".
(9) Nag, H. C. and Pain, A. E. *Trans. Bose Res. Inst.*, 1937-39, **13**, 175.
(10) Pain, A. E. *Trans. Bose Res. Inst.*, 1936-37, **12**, 65.
(11) Russell, R. J. "Soil Conditions and Plant Growth". London: Longmans, Green and Co. 1932.
(12) Bourne, C. L. C. "Some Preliminary Experiments on Phosphate Fixation in British Guiana Sugar-cane Soils". *Sug. Bull., Georgetown*, 1941, No. 10, 50-61.
(13) Hardy, F. and Hewitt, C. W. "A preliminary Investigation into Nitrification in British Guiana Sugar-cane Soils". *Tropical Agriculture*, 1949, **25**, Nos. 1-12, 38-40.
(14) Williams, C. H. B. and Follett-Smith, R. R. *Report of Chemistry Division, Department of Agriculture, British Guiana*, 1933, 93.

Myrobalans: An Important Tanning Material

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1. Introduction

Myrobalans are the dried fruit (Fig. 1) of an Indian Combretaceous tree, *Terminalia chebula* Retz., and they are used extensively for tanning. The ripe fruit is a hard yellow to orange-brown drupe, 3–5 cm. in length, obovoid, ellipsoidal or ovoid in shape, and sometimes tinged with red or black. When dry the fruit becomes five-ribbed. The seed or nut is 1·6–2·0 cm. by 1·25–1·5 cm., ovoid in shape, pale yellow, rough, hard and sub-angular. Thirty-five to forty-five fresh fruits, or sixty to seventy-five dry fruits weigh 1 lb.

The word form "myrobalans" is etymologically correct ("Shorter Oxford English Dictionary", 1933; Procter[1]), and this choice of spelling is further substantiated by the spellings used in the following manuscripts of the early Middle Ages: *the Antidotarium of Nicolaus Praepositus* (*Pil. de quinque generibus mirobalanorum*), *Matthaei Platearii glossae in antidotarium Nicolai* (*Pil. de quinque generibus myrobalanorum*), and *Otho Cremonensis* in his poem to the *Regimen Salernitanum* (*myrobalani*). Procter[1] cites "myrabolans" and "myrabolam(s)" as incorrect spellings, but the word form "myrabolam" which is colloquially abbreviated to "myrabs" is often used in the leather trade.

In addition to the extensive use of myrobalans in the tanneries of India, the annual export to other countries often exceeds forty thousand tons. As the constituents of this very important crop have recently been the subject of extensive chemical investigation, the present review has now been prepared.

2. Botany

Taxonomic considerations (Terminalia *species which are exploited commercially*).

The myrobalan of commerce is the product of *Terminalia chebula*, but Edwards, Badhwar and Dey[2] consider that in addition to the dried fruit of *T. chebula*, those of *T. citrina* Roxb., *T. travencorensis* Wight et Arn., and *T. pallida* Brandis are also probably involved. Although the dried fruits of *T. bellirica* Roxb., *T. citrina* and *T. pallida* (Figs. 2, 3, 4) were shown to have the same characteristic pattern of phenolics and tannins as authentic myrobalans[3], their tannin content (25–35 per cent. tannin, hide-powder test) was inferior to myrobalans (43–53 per cent. tannin, hide-powder test). The inferiority of the fruits of *T. citrina* in this respect has previously been mentioned by Pilgrim[4], as well as in the *Bulletin*

of the Imperial Institute[5]. The foregoing species mentioned merge into one another in their hybrid forms, and authenticated species can be differentiated only by the expert silviculturist.

Clarke[6] mentions six varieties of *T. chebula*, but his classification is now considered to be untenable. Thus, he cites a variety *typica* as common to Burma, Ceylon and India, whereas in the expert silviculturist's judgement all Indian specimens differ from all Burmese ones, and in extreme cases, they appear to be different species. These extreme forms merge, however, and such species as *T. argyrophylla* King et Prain and *T. pallida* are scarcely more than forms or varieties of *T. chebula*. In this connection, Gagnepain[7] reduces *T. citrina* to a *T. chebula* variety.

In Burma the myrobalan tree was originally described by Kurz as *T. tomentella*, but Hooper and Brandis united *T. tomentella* with *T. chebula* as a single species. Blatter[8] considered *T. tomentella* as a form of *T. chebula*, however, and he also considered *T. tomentosa* Wight et Arn. in India and *T. villosa* in Bihar as distinct forms. The present consensus of botanical opinion considers that the Burmese tree is a distinct species.

In general, myrobalans from Salem are higher, and those from Burma are lower in tannin content than the average for myrobalans. There are probably significant differences in the tannin content of the myrobalans collected from the various botanical species and varieties which have been mentioned, but these values are further complicated by such factors as the site of growth, the time when the fruit was harvested, and its subsequent drying treatment.

Habitat and Ecology

T. chebula grows throughout the Indian sub-continent. Under favourable conditions, the tree grows in the high forest in mixed deciduous stands, but on poorer soils, in regions where the rainfall is light, and at considerable elevations, the tree is a small one. In Burma, it grows in mixed deciduous forests in association with teak (*Tectona grandis*), *Terminalia tomentosa*, and other *Terminalia* species, and it is found in other forests mixed with gurjun (*Dipterocarpus tuberculatus*). In Assam, *T. chebula* grows at the base of the outer hills in association with sal (*Shorea robusta*) and *Lagerstroemia parviflora*, and it grows in the valleys in pure stands and in mixture with *Pinus longifolia*. Under more extreme conditions, the tree is characteristic of some types of dry forest, and it also grows at altitudes extending to 5,000–6,000 ft. in the outer Himalayas and in Travancore. This tree has to withstand an absolute maximum shade temperature of from 98°–118°F., a minimum temperature of from 30°–60°F., and a normal rainfall of from 30–130 in.

Morphology and Life-cycle

T. chebula is a moderately large-sized deciduous tree, of from 80–100 ft. in height[6], and the profile has a rounded crown. The trunk is usually short, and carries spreading branches, but, in Burma, it often grows straight and tall. The bark, which is dark brown and cracked longitudinally, is $\frac{1}{4}$ in. thick[9], and exfoliates in woody scales. The very hard heartwood is put to agricultural uses.[9] Leaves, which are 4–5 in. in

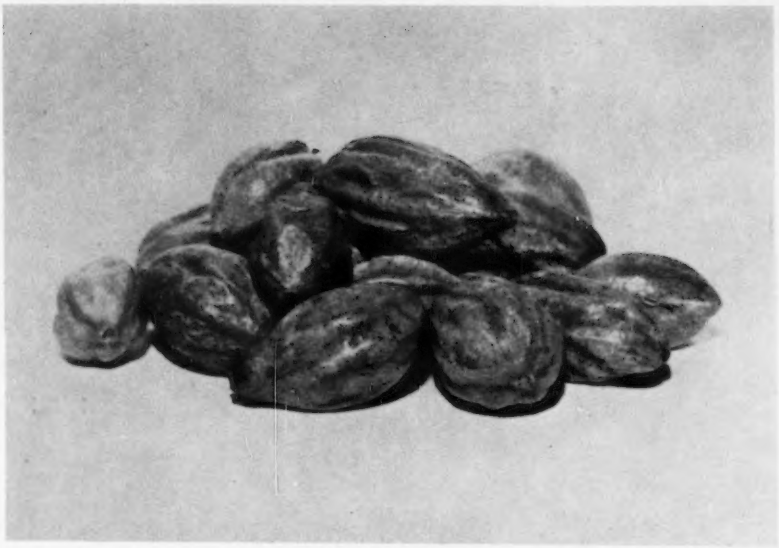


FIG. 1. Myrobalans from authentic *Terminalia chebula*

FIG. 2. Belliric myrobalans, the dried fruit of *Terminalia bellirica*

[*facing page* 86

FIG. 3. The dried fruit of *Terminalia citrina*

FIG. 4. The dried fruit of *Terminalia pallida*

length, are deciduous in the cold season, and are more or less hairy when young. They are not clustered, and are often subopposite, ovate or elliptic, acute not acuminate, and rounded at the base. The petiole is 1 in. long and often has two glands at the summit.

The tree generally begins to lose its leaves in November, and by February or March, it is leafless. New light green leaves commence to grow from March to May, accompanied by the appearance of terminal and often panicled spikes of greenish-white flowers. The flowers are hermaphrodite. In the young spikes, the bracteoles are conspicuous and more pubescent than the flowers, but they are deciduous at an early stage in the development of the flower. The calyx-teeth of this flower are hairy within. According to the locality, fruits ripen from November to March, and they fall soon afterwards.

Germination is epigeous. The hard putamen divides into two, and the radicle emerges from one end. The cotyledonary petioles elongate, arch slightly, and raise the cotyledons above the ground. These cotyledons are convolute in the seed, but unroll on emerging. The young stem grows out from between the cotyledons, and the discarded putamen remains on the ground.

Troup[10] gives a detailed botanical description of the young seedling.

These seedlings become 4–8 in. in height at the end of the first season, and 1–2 ft. in height at the end of the second one. The young plants are fairly resistant to frost.

Silvicultural Characteristics

The wide distribution and varied habitat of *T. chebula* implies that it is a light demander. The question of the effects of pure *T. chebula* crops on the soils is of importance in view of the large areas involved, but, in the absence of the relevant data, it would be unsafe to entertain opinions on this matter. The observation that there are whole areas where natural regeneration is very meagre, may be related to soil deficiency arising from the continuous growth of this crop. The tree is pretty hardy to drought and frost and it coppices fairly well.

Establishment Technique

The germinative power of the seed is very poor, and whole fruits as well as nuts invariably yield bad results. For artificial reproduction, it has been observed that the fruits should be collected from the ground immediately they fall, and they should not be picked from the tree for this purpose. Artificial reproduction is never highly effective, and it clearly requires further investigation. Optimum results obtain when the ripe fruits are dried, the hardened pericarp removed, and the nuts planted in boxes of well-watered soil before the rainy season. Nurseries which adopt this method for raising young plants achieve 20 per cent. germination. Transplanting can be carried out successfully during the first or second rainy season.

Rate of Growth

T. chebula is a slow-growing species. Coppice measurements on several

sites show that a five-year-old plant averages from 8 ft.–8·5 ft. in height. In older trees, six to ten rings usually occupy 1 in. of radius, which represents a mean annual girth increment of only 0·6–1·0 in.[9]

Pests and Diseases

Insects. The fruit is very liable to attack by insects, especially by white ants. Considerable damage is sometimes done to the leaves of trees growing in Madras by the bagworm moth (*Acanthopsyche moorei* Heyl)[9].

Fungi. No specific diseases have been recorded.

Mammals. Porcupines, rats and squirrels are commonly found on sites where *T. chebula* grows, and besides eating the ripe fruit, they also devour the young cotyledons of the germinating seedlings as soon as they appear above the level of the forest floor[11]. During the period of establishment, the young trees require protection from goats which feed on the young leaves.

Other Forms of Damage

T. chebula is a reasonably windfirm tree, which also has good powers of recovery from forest fires.

Fruit Bearing

A tree produces an average annual yield of fifteen to twenty pounds of fruit in each fruiting year. The yield per acre cannot be assessed, since these trees are not grown in plantations.

Natural Regeneration

The seed or nut germinates in the shade better than in the sun, and it retains its fertility to a diminishing extent for one year. Fallen fruits become partially buried by rain, and the adjacent soil becomes blackened by the tannin which leaches from them. The fleshy pericarp is eaten by white ants or disintegrates, leaving the hard nut exposed. Germination occurs in the rainy season, and is more likely to take place in cases where the nut has become covered with plant debris or soil.

3. Occurrence

Although *T. chebula* is found throughout the greater part of India, supplies of myrobalans from the Punjab and the Uttar Pradesh are all used locally, and Assam, Bengal and the dry north western part of the country do not produce many.

Myrobalans are collected from trees found in government and private forests, and on marginal land. Figures are available for the output from Government forests, but Edwards, Badhwar and Dey[2] consider that four or five times that quantity are collected from the other sites. These authors cite the following Government forests as being the ones most notable for the export of myrobalans:

Madhya Pradesh and Berar: Balaghat, north and south Mandla, north and south Raipur, Chhindwara, Melghat, Betul, Jubbulpore, and Amraoti.

Madras: upper Godaveri, Vizagapatam, Madura, Vellore, Tinnevelly, north and south Cuddapah, north Coimbatore, Kurnool, the Nilgiris and Salem.

Bombay: Belgaum, Poona, Satara, east Thana, Kanara west, east and west Nasik, and Kolaba.
Bihar: Singhbum, and Santhal Paraganas.
Orissa: Parlakimedi.

The bulk of India's crop of myrobalans is, therefore, exported from Madras and Bombay, with a smaller quantity from West Bengal.

4. Methods of Production in the Country of Origin

Time of Collection

Myrobalans are collected before or at the climacteric[12,2,13] and in this connection an old investigation by Puran Singh[14] may be cited, in which it was concluded that January is generally the best month for the collection of myrobalans in respect of their tannin content. Puran Singh did not, however, relate the time of collection with the state of ripeness of the fruit, which according to site and locality, ripens at different times throughout the Indian sub-continent. It is possible that the quality of the product would be considerably improved by greater standardization of the time of harvesting, relative to the state of ripeness of the fruit. The present practice of collection between October and March incurs suspicion. The fruits may be picked from the tree, i.e., immediately before the climacteric, but more frequently the tree is shaken, and they are collected from the ground[15]. Ripe fruits which have already fallen to the ground are also probably included with the others, provided that they have not already undergone obvious deterioration. In some parts of India, branches are cut off the tree, and the fruits are collected from them, but as the tree thereby sustains injury, this procedure is not practised extensively. According to "Tanning Materials of the British Empire"[16], "Bhimlies" and "Jubbulpores" (see below) are collected in the green, unripe condition, whereas the less esteemed Bombay fruits are gathered when ripe.

Agency for Collection

A myrobalan contractor purchases the right to collect the fruit from a defined locality for the season of harvest, and he buys the fruit, which the villagers collect, mostly in their leisure time. The contractor sells the dried fruit to merchants who supply the exporters and local tanneries. This age-old method of collecting the fruit is more economical than systematized departmental collections[17,11].

Drying Process

The fruit is spread out at the depot on ground which has been specially prepared, and exposed to the tropical sun. An earth floor resembles the clean type of threshing-floor used in the East in that it is flat, well-trodden, and all grass, loose dirt and sand have been removed. The crop, or "hirda" is spread in a single layer over the ground, and it is turned over at regular intervals to ensure drying in direct sunlight. On such an earthen floor, the period of drying occupies 20 days. On a rocky floor, drying is complete within 10 days, since heat is retained by this surface after sunset, and dew also evaporates more rapidly from the surface. In the event of rain,

the contractor temporarily stores the crop in sheds. When dry, the fruit is a little larger than half its original size. During drying the fruit becomes characteristically five-ribbed, and the pericarp becomes hard enough to resist the blade of a penknife. The valuable, dry "hirda" is packed into bags. If kept dry and free from contamination, sound myrobalans which have been prepared in this way do not deteriorate.

Sorting

Myrobalans are graded by the trade. Five different commercial varieties are known on the export market, which are named after the districts where they are marketed:

"Bhimlies"	from Bhimlipatam, Madras;
"Jubbulpores"	from Jabbalpur in the Madhya Pradesh;
"Rajpores"	from Kolhapur State, Bombay;
"Vingorlas"	from Bombay forests;
"Madras Coast"	

There are usually two grades of each variety. The best-looking fruit is picked out and the two grades thus obtained are marketed as "ones" and "twos". Standard samples of B–1 (Bhimlies 1), J–1 (Jubbulpore 1), R–1 (Rajpores 1) are crushed and retained by the Director of Industries in Bombay, and samples of J–1 are crushed and retained by the Director-General of Commercial Intelligence and Statistics, in Calcutta.

A special "picked" grade is sometimes sorted, and the average produce from any forest is often marketed as FAQ, fair average quality.

Myrobalans from Salem are the best, both for the high level of their tannin content, their pale colour and for the paleness of the extract obtained from them.

Many analyses have been published for the tannin content of the commercial varieties[18,16] and the following figures recorded in the laboratories of the B.L.M.R.A. may be of interest:

Tannin Analyses of Notable Commercial Varieties

	Kernel as approx. percentage of whole fruit.	Percentage tannin on a moisture-free and kernel-free basis.
Salem . .	25	52·3
Bhimlies, B–1 .	40	42·0
Rajpores, R–1 .	35	43·6
Jubbulpores, J–1 .	30	41·2
Ceylon . .	30	40·0

There seems to be no evidence that some varieties have better tanning properties than other ones (cf., "Tanning Materials of the British Empire". 1929). The grading system is subject to the criticism that it is based on appearance, and the Special Committee on Hides and Tanning Materials in England[19] and the Indian Government Trade Commissioner in New York[20] have drawn attention to this matter. The English Committee further recommended an evaluation based on the tannin analysis of the

fruit, and on the colour measurement of the extract. In world markets there is, however, no substitute for myrobalans, and the time-honoured method of sorting continues to be practised.

Crushing

As the kernel or nut of the fruit constitutes from 20–50 per cent. of the fruit, and contains only 2–4 per cent. tannin, its removal furnishes a product containing about 20 per cent. more tannin, and at the same time effects a considerable economy in freight. Crushed myrobalans are considered to have a tannin content of 40–45 per cent. The crushed product, which was introduced just before World War I, was slow to find favour with British tanners, particularly owing to the fact that the material in this form lends itself to adulteration, and contamination with low grade fruits. Crushed myrobalans are quoted regularly on British markets at a price which exceeds that of the whole fruit by approximately 10 per cent. A crushed product (No. 1), which conforms to international standard, is marketed, and has more or less guaranteed tanning characteristics. The following prices for myrobalans are cited for the 31st July, 1958[21].

	per cwt.
Myrobalans, crushed No. 1 International standard	20/–
revised standard . .	19/9
dried fruit, J–1 . . .	17/6
„ „ B–1 . . .	19/6
„ „ R–1 . .	18/6

and they indicate also the range of commercial varieties and crushed products available in the United Kingdom to the British tanner.

Extract Manufacture

Myrobalan extracts is the only tanning extract made in India, and extract factories operate at Raniganj (Bengal), and at Kharagpur (Bhopal). The solid extract produced there, which contains approximately 55 per cent. tannin, has to compete commercially with crushed myrobalans, which contain 40–45 per cent. tannin. This extract generally suffers from the disadvantage that it imparts a darker colour to leather than an extract which can be carefully prepared from crushed myrobalans. Further, crushed myrobalans are often a little cheaper in price than imported myrobalan extracts.

5. Trade

From time immemorial, myrobalans have been used by the Hindus for the purpose of tanning. They have been exported to Western Europe since the early Middle Ages[22], but they were first exported in really large quantities during the latter half of the nineteenth century. The United Kingdom is the largest single importer, and consumes one-half of India's total export of myrobalans (see Table I). In the United Kingdom and in other European countries, the use of myrobalans has superseded that of sumac and plant galls, which possess similar tanning properties.

TABLE I

Export of Myrobalans (cwt.)

	1949/50*	1950/1*	1951/2*	1952/3*	1953/4*	1954/5*	1955/6*
U.K. . . .	514,002	410,423	456,517	202,222	367,795	443,662	252,394
Total Commonwealth countries	551,305	468,388	509,372	237,496	413,699		
Total Foreign countries . .	292,912	334,710	373,668	345,854	295,212		
Share of W. Bengal	18,167	67,622	70,142	56,760	43,518	21,705	15,879
,, ,, Madras .	642,876	476,998	556,824	389,762	524,569	669,438	351,078
,, ,, Bombay .	183,174	258,478	256,074	136,828	140,824	136,636	168,972
Total exports .	844,217	803,098	883,040	583,350	708,911	827,779	535,929

* April to March.

TABLE II

Export of Myrobalan Extracts (cwt.)

	1949/50*	1950/1*	1951/2*	1952/3*	1953/4*	1954/5*	1955/6*
U.K. . . .	1,894	42,916	58,401	43,754	26,208		
Total Commonwealth countries	9,350	51,963	68,704	55,628	40,108		
Total foreign countries . .	10,354	15,896	29,163	15,226	24,478		
Share of W. Bengal	19,704	58,932	89,729	54,128	50,990		
,, ,, Bombay .	—	8,927	8,128	16,726	13,597		
Total exports .	19,704	67,859	97,867	70,854	64,586	64,662	70,117

* April to March.

TABLE III

Total Consumption of Myrobalans and Myrobalan Extracts (cwt.) *taken from the "Annual Abstract of Statistics"* (1956)[23]

	1949/50*	1950/1*	1951/2*	1952/3*	1953/4*	1954/5*	1955/6*
U.K. . . .	348,000	354,000	506,000	364,000	390,000	452,000	420,000

* April to March.

TABLE IV

Export of Cutch and Gambier (cwt.)

	1949/50*	1950/1*	1951/2*	1952/3*	1953/4*	1954/5*	1955/6*
U.K. . . .	3,031	1,936	5,191	2,528	5,649		
Total Commonwealth countries	7,803	6,225	11,030	6,128	10,602		
Total foreign countries . .	755	697	911	1,093	2,626		
Share of W. Bengal	4,863	5,925	8,710	4,142	8,534		
,, ,, Madras .	666	—	791	1,739	232		
,, ,, Bombay .	3,029	997	2,440	1,340	4,462		
Total exports .	8,558	6,922	11,941	7,221	13,228	14,084	13,443

* April to March.

When it is considered that *T. chebula* is not intensively cultivated in plantations but grows wild in the forest, that this tree's annual yield of fruit per fruiting year is a very moderate one, and that some four-fifths of India's annual myrobalans crop is used locally, it will be realized what an enormous number of trees are involved in the production of myrobalans in India. When the other valuable trees of India's forests are taken into consideration, some picture of the store of wealth which these forests represent in the country's economy, is obtained. Table I shows that 60–80 per cent. of the exported myrobalans crop comes from Madras, 20–30 per cent. from Bombay, and the remaining 2–10 per cent. from West Bengal. Table II shows, however, that West Bengal produces practically the whole of the myrobalan extract which is exported from India, and it may be concluded that this extract is in fact made from locally grown myrobalans. The remainder of this export comes from Bombay. No extract is manufactured in Madras, the province with by far the biggest output of myrobalans. A variable proportion of the available extract is imported by the United Kingdom where the product finds a limited market. Table III shows the corresponding consumption of myrobalans and imported myrobalan extract in the United Kingdom, and these figures are in fair agreement with those summarized in Tables I and II for the export of myrobalans and myrobalan extract respectively. The annual figures in both these contexts refer to the twelve-monthly period, *viz.*, April to March. Table IV is of interest, since it summarizes the corresponding export of cutch and gambier. These are the only other tanning materials which were exported from India throughout this period (1949–1956), and their combined output is only 1–2 per cent. of that of myrobalans. During this period (1949–1956), no barks were exported from India for tanning purposes.

The import of myrobalans to the United Kingdom represents one-third of this country's annual import of tanning materials on a weight basis. Nearly the whole of the remainder consists of solid wattle extract.

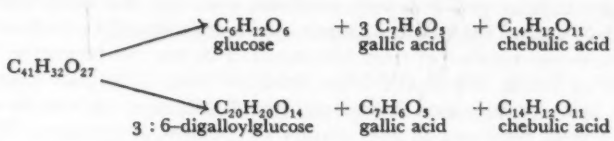
6. Properties

Chemistry of the Phenolics and Tannins

Reference to two-dimensional chromatograms[3] of the phenolics and tannins in methanolic extracts of myrobalans, specially collected in Ceylon and in the Bhimlipatam, Coimbatore, Jubbulpore and Kolhapur districts of India, showed that the hydrolysable tannins, chebulagic and chebulinic acids and corilagin are major constituents, and that they are accompanied by varying proportions of the following products of their complete and incomplete hydrolysis: chebulic acid, 3 : 6–digalloylglucose, ellagic acid, gallic acid and β–D–glucogallin.

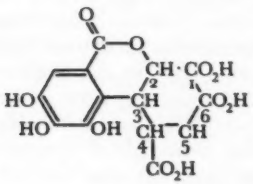
Chebulinic acid was the first gallotannin to be isolated in crystalline form[24,25]. It is a monocarboxylic acid, $C_{41}H_{32}O_{27}$[26] which was first reported as $C_{41}H_{34}O_{27}$. Acid-catalysed hydrolysis of chebulinic acid gives 1 mol. of glucose, 3 mols. of gallic acid and 1 mol. of an acid, $C_{14}H_{12}O_{11}$, which was eventually called chebulic acid. This acid was originally known as "Spaltsäure", and was wrongly formulated as $C_{14}H_{14}O_{12}$[27,28,29,30]. When chebulinic acid is partially hydrolysed by boiling water for 24

hours, 1 mol. of gallic acid, 1 mol. of chebulic acid and 1 mol. of digalloylglucose result[29,30]:

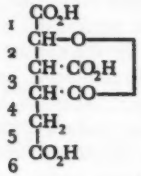


The constitution of chebulic acid (I) was initially investigated by Schmidt and Mayer[31], Mayer[32], Schmidt, Lademann and Himmele[33], and Schmidt, Heintzeler and Mayer[34]. Reference will be made only to salient features in the elucidation of the structure of this compound. Permanganate oxidation of chebulic acid in strongly acid solution at 0°C. gave a butanol tetracarboxylic acid, which was isolated as the crystalline lactone, $C_8H_8O_8$, (II).

Like the parent compound, chebulic acid, compound II is optically active. Synthesis of compound II by condensation of diethyl oxalate with

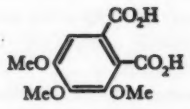


I

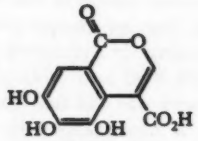


II

triethyl carballylate in the presence of sodium ethoxide, followed by Raney nickel hydrogenation gives an oily mixture of racemates[35]. Meanwhile, oxidation of tri–O–methylchebulic acid with potassium ferricyanide was found to yield more than 40 per cent. of the trimethoxyphthalic acid (III)[36]. This important evidence fulfilled the then-unproved structural requirement of Schmidt and Mayer's formula (I). Further proof that formula I represents chebulic acid was also provided by Haworth and de Silva[35] who obtained 5 : 6 : 7–trimethoxy*iso*coumarin–3–carboxylic (IV) and succinic acids by the pyrolysis of tri–O–methylchebulic acid in the presence of copper.



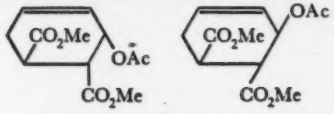
III



IV

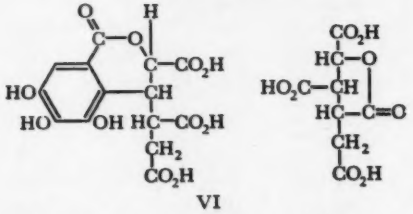
Dimethyl fumarate and acetoxybutadiene were reacted under vigorous conditions[37,38], and both modifications (V) of the resulting adduct were separated. Configuration was investigated by means of hydrogenation,

saponification and lactone formation. One form afforded a lactone, and it was therefore assigned the trans-trans configuration.



V

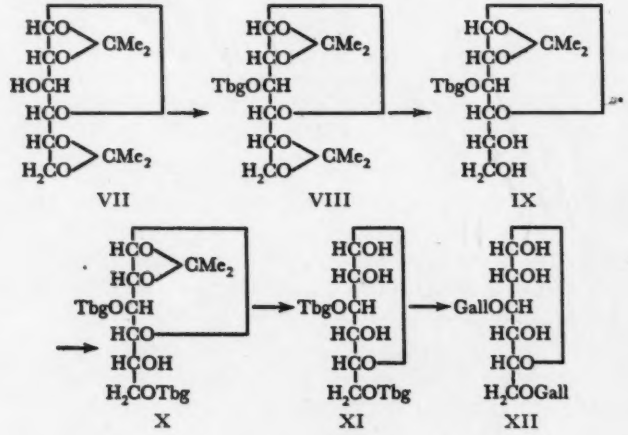
Ozone and hydrogen peroxide were used to cleave both racemates. The fission product derived from dimethyl trans-trans acetoxytetrahydrophthalate was resolved into antipodes. The m.p. and rotation, and the corresponding constants for the derivatives were identical with those values for the compound II. Compound, $C_8H_8O_8$ (II) and chebulic acid (I) therefore have the racemoido–racemoido configurations (VI).



VI

The absolute configuration of these substances is not yet known.

Freudenberg's digalloyl-glucose[39] was next examined by Schmidt, Berg and Baer[40], who prepared methyl and ethyl digalloyl-gluco-furanosides and pyranosides, and investigated their reactions with periodic acid. Finally Schmidt and Schach[41] synthesised 3 : 6-digalloylglucose by an unequivocal route, and showed that the crystalline synthetic and natural products were identical. This synthesis is exemplified by the reaction sequence VII–XII



VII VIII IX

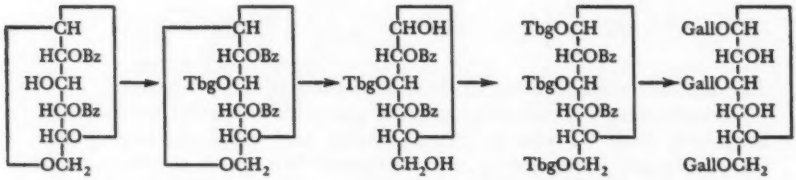
X XI XII

where Tbg = Tribenzylgalloyl; Gall = Galloyl.

By means of paper chromatography, the reaction between chebulinic acid and water at 60°C. can be shown to give rise to a sequence of products[42]:

$$C_{41}H_{32}O_{27} \xrightarrow{+\,H_2O} \underset{\textit{neo}\text{chebulinic acid}}{C_{41}H_{34}O_{28}} \xrightarrow{+\,H_2O} \underset{\text{trigalloylglucose}}{C_{27}H_{24}O_{18}} + \underset{\text{chebulic acid}}{C_{14}H_{12}O_{11}}$$

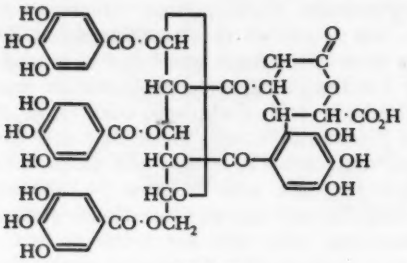
The new compound, $C_{41}H_{34}O_{28}$, neochebulinic acid is crystalline, and on hydrolysis it affords, like chebulinic acid, glucose, 3 mols. gallic acid and chebulic acid. Neochebulinic acid was further characterized by the preparation of tetradecamethyl and pentadecamethyl derivatives. Treatment of the pentadecamethyl compound with potassium methylate afforded 2–methyl–D–glucose. The new trigalloylglucose, which is amorphous, must contain the third galloyl residue in l-position, for the reaction with aniline hydrogen phthalate is only positive during the next hydrolysis to 3 : 6–digalloylglucose. This trigalloylglucose (XVII) has now been synthesized[43] starting from 2 : 4–dibenzyllaevoglucosan (XIII)[44]:



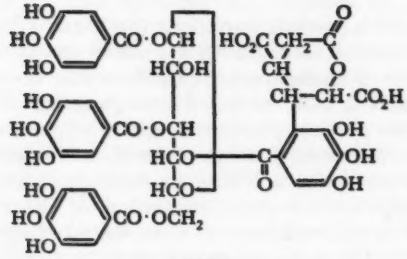
XIII XIV XV XVI XVII

where Tbg and Gall have the previously defined meanings.

According to Lindberg's method[45] for determining the configuration at the C_1 carbon atom, Schmidt, Demmler, Bittermann and Stephan[42] reacted undeca–acetyl–trigalloylglucose with boron trifluoride. By this reaction, β–glucosides are converted into their α–anomers, and transglycosidation is accompanied by a big increase in the positive value of the specific rotation, thus for β–D–glucogallin hepta–acetate, $[\alpha]_D$ is −24·1°C., whereas for α–D–glucogallin hepta–acetate, $[\alpha]_D$ is +104°C. In the present context, trigalloylglucose undeca–acetate has a $[\alpha]_D$–value of +13°C., and after BF_3–treatment, the $[\alpha]_D$–value rose to +80°C. Trigalloylglucose therefore has the β–configuration at the C_1 carbon atom. It therefore follows that chebulinic and *neo*chebulinic acids have the configurations XVIII and XIX respectively.



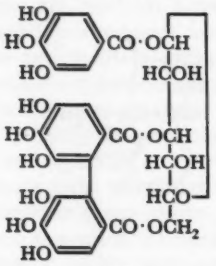
XVIII



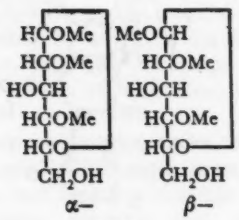
XIX

A brief account of the chemistry of the ellagitannins, chebulagic acid and corilagin, which have recently been isolated from myrobalans, will now be given.

Corilagin (XX) was isolated by Schmidt and Schmidt.[46] Hydrolysis with strong acid gave 1 mol. glucose and ellagic and gallic acids. Schmidt and Lademann[47] prepared an incompletely methylated product, which was further transformed into the hendeca-O-methyl derivative[48] by Purdie methylation. A hendeca-acetate was also obtained. Hydrolysis of the incompletely methylated product[49] afforded optically active 4 : 5 : 6 : 4′ : 5′ : 6′-hexahydroxydiphenic acid. Hydrolytic degradation of hendeca-O-methylcorilagin in chloroform at O°C. with 4 equivalents of potassium methoxide afforded methyl tri-O-methylgallate, and an amorphous octamethyl-(hexahydroxydiphenoyl)-glucose which by reaction with methanolic hydrogen chloride gave a mixture of the methyl α- and β-glucosides. Alkaline hydrolysis yielded a mixture of dimethyl-α-



XX



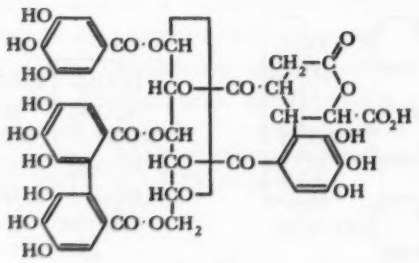
XXI

and β-methyl-glucosides (XXI), from which 2 : 4-dimethyl-β-D-methylglucoside was recovered in crystalline form. The configuration of the C_1 carbon atom of corilagin was found to accord with that of the β-glucoside, by Lindberg's BF_3 transglycosidation reaction[45].

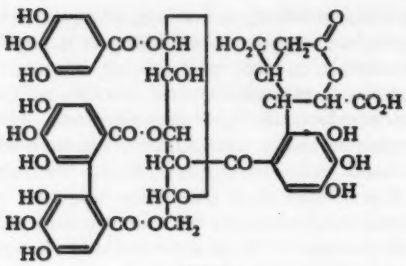
The monocarboxylic acid, chebulagic acid, $C_{41}H_{30}O_{27}$, was isolated by Schmidt and Nieswandt[50], who found that acid hydrolysis afforded 1 mol. of glucose and chebulic, ellagic and gallic acids. Hydrolysis of trideca-O-methylchebulagic acid[49] gave (+) hexamethoxydiphenic acid, tri-O-methylgallic acid and tri-O-methylchebulic acid. The partial hydrolysis of chebulagic acid with hot water at 60°C.–90°C. afforded chebulic acid and corilagin[51]. Corilagin is therefore deschebuloyl chebulagic acid. By analogy with chebulinic acid, the chebuloyl residue of chebulagic acid is probably attached to C_2 and C_4 carbon atoms of the glucose residue of corilagin (XX). Since the C_1 carbon atom of corilagin is in the β-configuration, it follows that the C_1 carbon atom of chebulagic acid is also in the β-configuration. A more intensive investigation of the partial hydrolysis by means of paper chromatography and polarimetry, indicated that an intermediate compound was formed from chebulagic acid prior to hydrolytic fission, and this compound was isolated by Craig countercurrent extraction of the reaction mixture obtained by 78 hours' treatment of the original ellagitannin with hot water at 55°C.[52] The new compound which was called *neo*chebulagic acid has the following properties:

	Empirical formula	m.p.	$[\alpha]_D$ in ethanol
*neo*chebulagic acid	$C_{41}H_{32}O_{28}$, $9H_2O$	196° C.	− 102° C.
chebulagic acid	$C_{41}H_{30}O_{27}$, $10H_2O$	>240° C.	− 57° C.

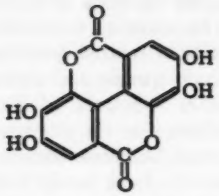
With diazomethane, *neo*chebulagic acid, which is a dicarboxylic acid, formed a crystalline tetradeca-O-methyl derivative, which by Purdie methylation afforded the amorphous, fully methylated pentadeca-O-methyl *neo*chebulagic acid. Treatment of this compound with potassium methoxide afforded in addition to the methylated aromatic carboxylic acids, 2-methyl-D-glucose which was isolated from the reaction mixture by successive ion-exchange and cellulose column chromatography. 2-Methyl-D-glucose was identified as the crystalline phenylhydrazone[53]. Schmidt, Hensler and Stephan [52] therefore assigned the structural formulae XXII and XXIII to chebulagic and *neo*chebulagic acids respectively.



XXII



XXIII



XXIV

In a study of the transformation of gallates into ellagate under physiological conditions, Hathway[54] found that a solution of chebulinic acid (XVIII) at pH 7–8 underwent aerobic oxidation. 0·6 mol. of ellagic acid (XXIV) was formed indicating that the galloyl residue in the 1 β–position of the gallotannin was hydrolytically oxidized to ellagic acid (XXIV). Addition of mushroom polyphenoloxidase did not affect the rate of this reaction, since the initial preponderance of tannin inactivated this enzyme. This demonstration of the oxidative removal of the galloyl residue of chebulinic acid explains why a neutral aqueous solution of myrobalans extract deposits ellagic acid on storage.

From the results of this *in vitro* study, it follows that free ellagic acid may be formed in myrobalans after abscission by the aerobic oxidation of the methyl gallate, β–D–glucogallin or chebulinic acid metabolites, as well as by the hydrolysis of the ellagitannins, chebulagic acid and corilagin.

Acid-catalysed hydrolysis of myrobalans ellagitannins slowly occurs in the tan-liquors in standard tannery practice, and gives rise to insoluble ellagic acid with simultaneous loss of utilizable "tannin".

Amino Acids, Fruit Acids, and Polyols

A qualitative and exploratory study of the amino acids, plant acids and polyols of myrobalans has been made[3]. After removal of phenolics and tannins from an 80 per cent. (v/v) aqueous methanolic extract of the dried fruit, the remaining constituents were divided into neutral, basic and acidic fractions by ion-exchange chromatography, the amino acids isolated after electrolytic desalting of the basic fraction, and paper chromatographic methods were used for the provisional identification of constituents in the three fractions.

Glucose and hexitol (sorbitol) predominate in the neutral fraction which constitutes approximately 10 per cent. by weight of the dry fruit. These fruits also contain about 1 per cent. each of fructose and sucrose, a smaller quantity of gentiobiose, and traces of arabinose, maltose, rhamnose and xylose.

Alternative pairs of solvent systems were selected in order to resolve on one chromatogram those amino acids which were incompletely separated on the other. The amino acids thus identified include alanine, γ–aminobutyric acid, arginine, asparagine, aspartic acid, cysteine,

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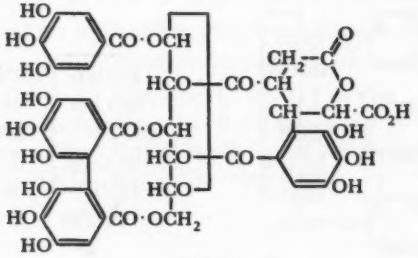
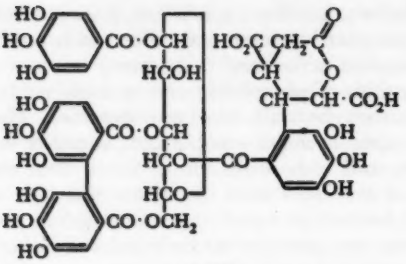
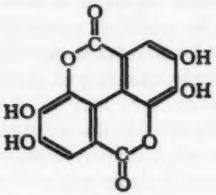


XXII



XXIII



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glutamic acid, glutamine, glycine, histidine, *iso*leucine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine and valine. It is possible that all eighteen of these substances occur free in the living trees.

In addition to small quantities of phosphoric and succinic acids, a family of related *cyclo*hexanecarboxylic acids has been identified. These include quinic and shikimic acids as major constituents, together with smaller amounts of dihydro- and dehydro-shikimic acids. Tentative evidence for the occurrence of a related ester phosphate was also advanced. Dihydroshikimic acid has not previously been detected in plant tissue. In later work[55] shikimic and quinic acids were isolated from the plant acids by means of more detailed ion-exchange chromatography.

The nature of the constituent amino acids, fruit acids and polyols of myrobalans were discussed against the contemporary background of authenticated plant products[3].

There is a strong supposition[3,55] that the structurally related *cyclo*hexanecarboxylic acids are formed by the plant as intermediates of aromatic biosynthesis, leading to the aromatic amino acids, and the simple polyphenolic units from which the tannins of the *Terminalia* spp. are elaborated.

Cell-wall Polysaccharides

In this study[56], the cell-wall polysaccharides were fractionated by a series of analytical operations which afforded fractions of mixed polysaccharides. These fractions were hydrolysed by the methods of Jermyn and Isherwood[57], and the corresponding monosaccharides were separated by paper chromatography and estimated by established methods. For myrobalans, it was readily established that the galacturonic acid can be accounted for as polygalacturonic acid, and the bulk of the glucose as cellulose. The remainder of the glucose is derived from starch, which is treated by the analytical procedure as a cell-wall constituent, and which is consequently omitted from the cell-wall polysaccharides. The polygalacturonic acid figure (1·9 per cent. in the moisture-free fruit) was checked by the calcium pectate method, and also by the isolation of the polyuronide. Hydrolysis of the isolated cellulose fraction showed that it was virtually pure polysaccharide. The only other sugars present in the hydrolysates are traces of mannose and xylose, which correspond to the presence of small quantities of mannan and xylan in the cell-wall.

The high cellulose and lignin contents of the cell-wall (8·0 per cent. and 3·0 per cent. respectively in the moisture-free fruit), and the enormous cellular content of tannin extractives, are consistent with the fact that the dried fruit cannot be cut with a knife. Myrobalans which are picked before or at the climacteric[12,2,13] have subsequently undergone autolysis, accelerated by storage under tropical conditions, and this is confirmed by the presence of "pectins" soluble in cold and hot water. The absence of arabinose and the presence of only a very small proportion of xylose in the hydrolysates of the cell-wall fractions, show that hemicellulose components are virtually absent from myrobalans. This also applies to galactan. Although such hemicellulose and galactan may have undergone

rapid physiological change in the isolated tissue during drying, the absence of galactose, and the presence of only trace quantities of arabinose and xylose in the polyol fraction of the extractives[3] suggests that the hemicellulose content of the myrobalans cell wall may have never been high. In agreement with the fact that a significant quantity of holocellulose glucosan becomes labile during senescence, a proportion of this glucosan was found in the soluble fractions.

It is difficult away from the country of origin to attempt to follow the changes which occur in the cell-wall polysaccharides during the ripening of myrobalans. The methods developed in the work discussed, however, are eminently suitable for this project.

The Influence of Tannins on the Degradation of Pectin by Pectinase Enzymes

Pectolysis of pectic acid by commercial enzyme preparations[58] leads to a series of oligogalacturonic acid intermediates up to the decamer, and eventually to D–galacturonic acid, whereas the enzymic hydrolysis of myrobalans or apple pectin affords D–galacturonic acid alone. These pectolytic acids found may be explained in terms of endopolygalacturonase (endo–PG), exopolygalacturonase (exo–PG) and exopolymethylgalacturonase (exo–PMG). Endo–PG attacks low-methoxy pectin by a random mechanism of hydrolysis which leads to intermediate oligogalacturonic acids and eventually to digalacturonic acid, whereas exo–PG removes terminal galacturonic units from the substrate and its intermediate polyuronides, and cleaves digalacturonic acid Exo–PMG attacks pectin by a terminal mechanism of hydrolysis. Viscometric measurement shows that myrobalans tannins exert a powerful inactivation on the early stages of the pectolysis of pectic acid, but only a slight retarding action on the pectolysis of pectin. The fact that these enzymic hydrolyses go to completion in the presence of myrobalans tannins is consistent with the ripening of the fruit, and the retarding action exerted by these tannins on the action of the pectolytic enzymes explains why sound, dry myrobalans can often be collected from the forest floor.

Seed Lipids

Sunthankar and Jatkar[59] have made a preliminary investigation of the seed fats by classical methods. Their analyses shows that 59 per cent., 23 per cent. and 18 per cent. by weight of the component fatty acids comprise. oleic, linoleic, and palmitic plus stearic acids respectively. The seed fat falls into the edible class, but is present in too small a quantity to be worth exploiting. Sunthankar and Jatkar's exploratory study is worthy of further investigation by the modern methods of separation now available.

Preparation of Commercial Tanning Extract

In general, extractives are removed from plant tissue by the maceration or homogenisation of the tissue in organic solvent, water or aqueous buffer, or by the percolation of solvent, water or aqueous buffer through the finely-minced tissue. Where the chemical nature of the extractives permits, the efficiency of these processes is often enhanced by the

application of heat. Heat is more readily applied to the percolation system, and this process is employed for the leaching of phenolics and tannins from vegetable tanning materials with water.

The present counter-current diffusion or extraction system is a logical development of the percolation system. A suitable number of open wooden vats (Figs. 5, 6)[60] are situated above floor level for the convenience of removing the spent fruit tissue. They are connected with non-ferrous metal pipe-line and have by-pass valves to control the flow of the extracting medium[60]. Hot water is pumped into the vat containing the most extracted fruit, and this liquor is eventually transferred to the next vat in the series by means of intermediate pumps. Heat exchangers are accommodated in the pipe-line connections between one vat and the next one in order to maintain the temperature of the extracting medium where required. In practice, these exchangers are often copper spirals through which steam is passed[60], and they are situated either immediately above the false floor of the vat which holds the charge of fruit, or between the false floor and the bottom of the vat. According to the setting of the valves, the pumps may be used to draw off liquor from the bottom of the vat and return it to the top of the same vat for further circulation of the extract through the fruit, or they may conduct the extract to the fruit in the next vat in series. When a charge of fruit has been completely extracted of its phenolic and tannin extractives, the vat is removed from the countercurrent extraction system, and the water-insoluble cell-wall material is discharged manually.

Complete countercurrent extraction of a battery of six open wooden vats (Fig. 5) charged with myrobalans, takes from 24–30 hours. The fresh, unextracted fruits are extracted with extracting medium at 60°C. whereas the almost "spent" fruits are extracted with water at approximately 80°C. Optimal temperature conditions for the non-destructive extraction of myrobalans tannins were investigated by Cheshire[61], and the conditions of the commercial countercurrent extraction are a realistic interpretation of these results. In relation to the overall economics of extract manufacture, the extract liquor which is finally withdrawn from the countercurrent battery should contain the maximum concentration of tannin, otherwise the extensive evaporation of the liquors which would be obtained, makes the operation of the process unattractive. This implies that the volume of water which is used for the countercurrent extraction of a unit charge of fruit, must be kept at a minimum.

The kernels are removed from whole myrobalans, and both whole and crushed myrobalans are further disintegrated prior to extraction. Dust and earth particles are rejected, and iron particles are removed in a magnetic separator. It will be apparent that the state of division is a factor important to the economic extraction of the fruit. Rough homogeneity of size is ensured by sieving, and the resulting material is slurried with water, and conducted to the vats for countercurrent extraction. Such finely-divided fruit offers uniform resistance to pulping during extraction.

The disposal of the water-insoluble cell-wall material depends on the proximity of the extract factory to such industries as exploit waste fibrous

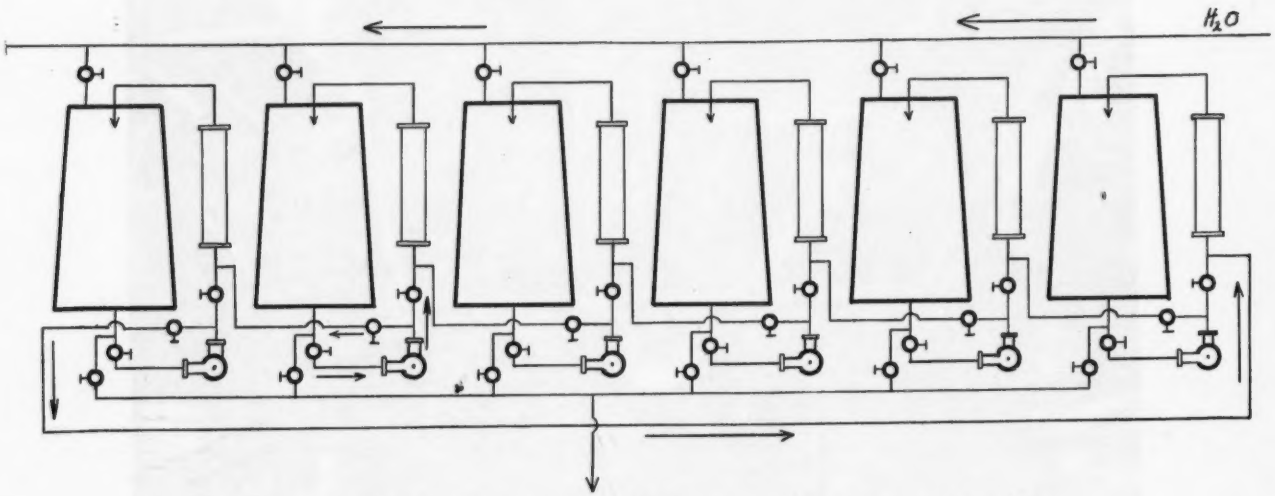
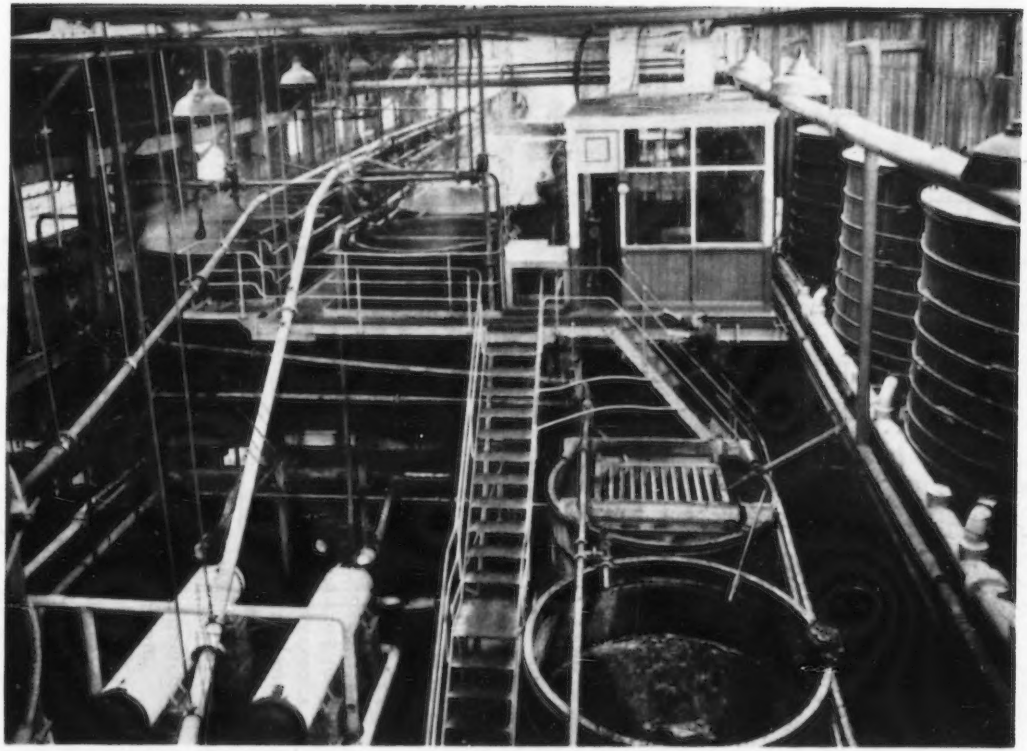


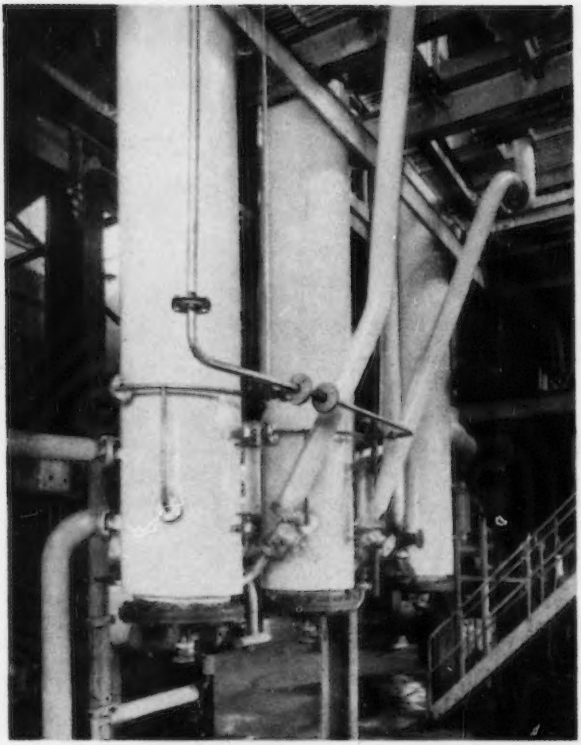
FIG. 5. A battery of open vats connected for the purpose of countercurrent extraction

[facing page 102



[*Courtesy: Richard Hodgson and Sons Ltd., Beverley, Yorks.*

FIG. 6. Three batteries of open wooden vats for the countercurrent extraction of myrobalans



[*Courtesy Richard Hodgson and Sons Ltd., Beverley, Yorks.*

FIG. 7. A bank of multi-effect evaporators used for the evaporation of myrobalans leach liquor

[*Courtesy: Walker and Sons, Ltd., Bolton*

FIG. 8. Butts being lifted out of tan-pits in a sole leather tannery

materials. Such fibre has a limited use, and a nominal value for the production of low-grade papers. Very often the cell-wall material is used as auxiliary fuel. It is possible to burn this cell-wall material with the aid of low-grade coal at the moisture content of the material when it leaves the vats. Alternatively, waste flue gases from the boilers may be used to expel most of the water from the cell-wall debris. The resulting material can then be introduced into furnaces, designed for the combustion of dry materials.

Extract liquor which is finally withdrawn from the countercurrent extraction system is allowed to stand in large settling tanks prior to evaporation. By these means a certain amount of finely suspended ellagic acid is deposited. Such settling is beneficial, since the ellagic acid adsorbs some pigment and pigment degradation products, which are removed from the system when the crude ellagic acid is tapped from the bottom of the settling tanks.

Extract liquor from the settling tanks contains approximately 20 per cent. concentration of extractives. This liquor is pumped to a bank of Kestner triple or quadruple effect evaporators[60] (Fig. 7), in one of which it is evaporated at approximately 30°C. Evaporation in the Kestner evaporators is discontinued when the enriched liquor contains approximately 60–70 per cent. extractives. This liquor is an acceptable product, which is exported from the factory in sealed drums as myrobalans liquid extract. A good quality liquid extract contains 40–50 per cent. tannin (hide-powder test).

In addition to liquid extract, an extract factory also produces myrobalans powdered extract which contains about 10 per cent. moisture. For this purpose, partially evaporated liquor from the Kestner evaporators is atomized in a large cyclone, where the atomized droplets come into contact with a stream of hot air, which instantly evaporates the remaining moisture. The resulting powder falls to the conical-shaped bottom of the cyclone, where it is collected in double bags. The additions are adjusted by weight, and the lips of the bags thus filled are sealed for export. A cyclone evaporator copes with 10–14 cwt. of powder per hour. In the evaporator, particle size of the product is governed by the speed of the atomizing jets, which revolve at 10,000–15,000 rev./min.

Use of Myrobalans Extract in Heavy Leather Tannery Practice

The physical chemistry of vegetable tannage has been extensively investigated by Balfe and his collaborators, and excellent accounts of this work are readily available [62,63].

In modern tannery practice, the limed and bated hides are delimed in special pits with the agency of ammonium chloride, boric acid[64], formates or mineral acid. Vegetable tannage of the delimed and acid-plumped hides (Fig. 8) is then effected by means of a countercurrent process in which the liquors are circulated and the hides remain stationary. In Britain, the tannage for sole leather manufacture consists of a binary mixture of wattle and myrobalans, blended in the ratio of 2 : 1.

Some mention should be made of the special features of myrobalan

extract as a tanning agent. The cost of myrobalans in the United Kingdom market implies that myrobalans are comparatively inexpensive per unit of tannin. On the same basis, the cost of wattle is greater. In contrast to other commercial tanning materials, myrobalans contains a useful proportion of organic acid. Thus, a solution which contains 25 per cent. by weight of myrobalans extract is 0·5M-acid. A high proportion of myrobalans extract can therefore be used for pH control of the late liquors, and only small additions of mineral acid need be added to the early liquors. This method of acid control of the tannage is superior to methods which are solely dependent on the addition of strong acid. The quantities of acid which have to be added to the early liquors are small in comparison with the acidity which is contributed to the tan-liquors by the tanning-agents[65], notably myrobalans. The high acidity of myrobalans tanning extracts enforces a limit, however, to the proportion which can be used with impunity in the hot-pits[66,67]. In the early tan-liquors, salts derived from the acids and acidic tannins in myrobalans extract probably facilitate the penetration of tannin into the pelt. The tannin of myrobalans is not very astringent, however, and it penetrates the hide structure rather slowly. When used alone, myrobalans tannins yield a soft, mellow and rather spongy leather. Myrobalans extract is usually blended with wattle, the red colour of which is thereby masked, and a brighter more satisfactory colour is imparted to the leather. Myrobalans extract contains a high proportion of the ellagitannins, chebulagic acid and corilagin, which during tannage leads to the deposition of "bloom" (ellagic acid) in the grain of the leather. The yellow colour of leather which has a heavy deposit of bloom on the grain, often obscures a reddish-brown tint in the grain itself. Application of oil to the grain before the leather is dried causes the leather to retain a light colour by preventing the migration of water-solubles into the grain during drying. Myrobalans extract is therefore esteemed for its bloom-forming properties which are of special interest in the production of sole leather, which possesses a satisfactory colour. The colour (Lovibond Units) of a 0·5 per cent. solution of myrobalans extract, as used in the Official Methods of Analysis[68], is a feature of this tanning extract which makes this tanning material very suitable for the manufacture of heavy leather. Recent colour determinations which have been made in the laboratories of the British Leather Manufacturers' Research Association on some recent samples of myrobalans extract varied between 0·3 to 1·0 : (average 0·56) Lovibond Units for red and between 1·9 to 4·0 : (average 3·16) for yellow. No other widely-available commercial tanning material affords an extract which possesses such a low value for the red units, in this test. On the other hand, myrobalans is not considered as a very good weight-yielding tanning agent, as the proportion of tannin which combines with hide substance is small in comparison with that of such tanning materials as wattle. Further, myrobalans extract deposits sludge in the pits, which consists principally of chebulinic and ellagic acids, and which occludes other tannins. In the interests of tannin economy such losses of chebulinic acid and of other tannins are to be regretted.

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Bibliography

(1) Procter, H. R., "The Principles of Leather Manufacture", 2nd Edn. London: E. and F. N. Spon, 1922.
(2) Edwards, M. V., Badhwar, R. L. and Dey, A. C., *Indian For. Rec.*, 1952, **1**, No. 2.
(3) Hathway, D. E. (a), *Biochem. J.*, 1956, **63**, 380.
(4) Pilgrim, J. A., *For. Bull. Dehra Dun*, 1924, **56**, 29.
(5) *Bull. imp. Inst., Lond.*, 1924, **22**, 123; 413.
(6) Clarke, C. B., "The Flora of British India", 1879, **2**, 446. Ed. by Hooker, Sir J. D., London: L. Reeve and Company.
(7) Gagnepain, F., "Clef analytique et synoptique des familles de plantes vasculaires décrite dans la Flore générale de L'Indo-Chine. Paris": 1922, Rev. sci. Bourbon.
(8) Blatter, E., *J. Indian bot. Soc.*, 1929, **8**, 245.
(9) Gamble, J. S., "A Manual of Indian Timbers", 339. London: Sampson Low, Marston and Company, 1902.
(10) Troup, R. S., "The Silviculture of Indian Trees", **2**, 511-514. Oxford: The Clarendon Press, 1921.
(11) Hirda. "Information on correct methods of collection, preparation, etc., and propagation". *Indian For.*, 1931, **57**, 404.
(12) Chopra, R. S., *Indian For.*, 1939, **65**, 126.
(13) Howes, F. N., "Vegetable Tanning Materials", 165. London: Butterworths Scientific Publications, 1953.
(14) Puran Singh, *Indian For.*, 1915, **41**, 13.
(15) Choudary, K. S. and Nayudu, E. Y., *Madras For. Bull.*, 1929, **28**, 40.
(16) "Tanning Materials of the British Empire", 64-72. London: John Murray, 1929.
(17) Peyton, *Indian For.*, 1879, **5**, 225.
(18) Parker, J. G. and Blockey, F. A., *J. Soc. chem. Ind., Lond.*, 1903, **22**, 1181., 1338.
(19) *Report on the trade in Indian myrobalans. The Special Committee of the Indian Trade Enquiry on Hide and Tanning Materials*, 1922, *Indian For.*, 1922, **48**, 658-675.
(20) "Indian myrobalans in the American market". *Indian Trade Journal*, 1941, **141**, 736.
(21) *Leath. Tr. Rev.*, 1958, **129**, 217.
(22) Nierenstein, M., in "The Natural Organic Tannings" 196. London: J. and A. Churchill, 1934.
(23) *Annual Abstract of Statistics*, 1956, No. 93, 154. London: Her Majesty's Stationery Office.
(24) Fridolin, A. (a). *Diss. Dorpat.*, 1884.
(25) Fridolin, A. (b). *S.B. Dorpat Naturforsch. Ges.*, 1884, **7**, 131.
(26) Freudenberg, K. and Frank, T., *Liebigs Ann.*, 1927, **452**, 303.
(27) Richter, W., *Diss. Erlangen*, 1911.
(28) Richter, W., *Arb. pharm. Inst. Univ. Berl.*, 1912, **9**, 85.
(29) Freudenberg, K., *Ber. dtsch. chem. Ges.*, 1919, **52**, 1238.
(30) Freudenberg, K. and Fick, B., *Ber. dtsch. chem. Ges.*, 1920, **53**, 1728.
(31) Schmidt, O. T., and Mayer, W., *Liebigs Ann.*, 1951, **571**, 1.
(32) Mayer, W., *Liebigs Ann.*, 1951, **571**, 15.
(33) Schmidt, O. T., Lademann, R. and Himmele, W., *Chem. Ber.*, 1952, **85**, 408.
(34) Schmidt, O. T., Heintzeler, M. and Mayer, W., *Chem. Ber.*, 1947, **80**, 510.
(35) Haworth, R. D. and de Silva, L. B., *J. chem. Soc.*, 1954, 3611.
(36) Haworth, R. D. and de Silva, L. B., *J. chem. Soc.*, 1951, 3511.
(37) Schweiger, R., *Diss. Heidelberg*, 1954.
(38) Schmidt, O. T., "Symp. Soc. Leath. Tr. Chem. Vegetable Tannins", 1956, 67.
(39) Freudenberg, K., "Tannin, Cellulose, Lignin, 1933", 33, Berlin: Verlag von Julius Springer.
(40) Schmidt, O. T., Berg, S. and Baer, H. H., *Liebigs Ann.*, 1951, **571**, 19.
(41) Schmidt, O. T. and Schach, A., *Liebigs Ann.*, 1951, **571**, 29.
(42) Schmidt, O. T., Demmler, K., Bittermann, H. and Stephan, P., *Liebigs Ann.*, 1957, **609**, 192.
(43) Schmidt, O. T. and Klinger, G., *Liebigs Ann.*, 1957, **609**, 199.

(44) Zemplén, G., Csürös, Z. and Angyal, St., *Ber. dtsch. chem. Ges.*, 1937, **70,** 1848
(45) Lindberg, B., *Acta chem. scand.*, 1948, **2,** 426; 534.
(46) Schmidt, O. T. and Schmidt, D. M. (b). *Liebigs Ann.*, 1952, **578,** 31.
(47) Schmidt, O. T. and Lademann, R., *Liebigs Ann.*, 1951, **571,** 232.
(48) Schmidt, O. T., Schmidt, D. M. and Herok, J., *Liebigs Ann.*, 1954, **587,** 67.
(49) Schmidt, O. T., Blinn, F. and Lademann, R., *Liebigs Ann.*, 1952, **576,** 75.
(50) Schmidt, O. T. and Nieswandt, W., *Liebigs Ann.*, 1950, **568,** 165.
(51) Schmidt, O. T. and Schmidt, D. M. (a). *Liebigs Ann.*, 1952, **578,** 25.
(52) Schmidt, O. T., Hensler, R. H. and Stephan, P., *Liebigs Ann.*, 1957, **609,** 186.
(53) Brigl, P. and Schinle, R., *Ber. dtsch. chem. Ges.*, 1930, **63,** 2884.
(54) Hathway, D. E., *Biochem. J.*, 1957, **67,** 445.
(55) Hathway, D. E. (b) "Symp. Soc. Leath. Tr. Chem.: Vegetable Tannings", 1956, 99.
(56) Hathway, D. E. and Seakins, J. W. T. (a). *Biochem. J.*, 1958, **70,** 155.
(57) Jermyn, M. A. and Isherwood, F. A., *Biochem. J.*, 1956, **64,** 123.
(58) Hathway, D. E. and Seakins, J. W. T. (b). *Biochem. J.*, 1958, **70,** 158.
(59) Sunthankar, S. R. and Jatkar, S. K. K., *J. Indian Inst. Sci.*, 1938, **21A,** 149.
(60) Pawlowitsch, P., "Die Gerbextracte, Eigenschaften Herstellung und Verwendung", 142-151. Wien: Verlag von Julius Springer, 1929.
(61) Cheshire, A., *J. Soc. Leath. Tr. Chem.*, 1938, **22,** 452; 480.
(62) Balfe, M. P. (a). "Progress in Leather Science, 1920-1945", 1948, 564-622. Ed. by Jordan Lloyd, D. London: British Leather Manufacturers' Research Association.
(63) Balfe, M. P. (b). *J. Soc. Leath. Tr. Chem.*, 1948, **32,** 39.
(64) Pollak, L., Springer, W. and Patzenhauer, A., *Collegium, Haltingen*, 1937, **805,** 285.
(65) Balfe, M. P., *B.L.M.R.A. Monthly Digest*, 1944, **2,** 139.
(66) Brown, W. B., Cheshire, A. and Holmes, N. L., *Supp. Rep. Brit. Leath. Mfrs Ass.*, 1940, **1,** 18.
(67) Cheshire, A., Brown, W. B. and Holmes, N. L., *J. Soc. Leath. Tr. Chem.*, 1941, **25,** 254.
(68) *Official Methods of Analysis*, Croydon: The Society of Leather Trades' Chemists, 1947, 14.

Methods for the Reduction of Evaporation from Water Surfaces

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In large areas of the world, particularly the tropics, shortage of fresh water is the factor limiting human habitation and agricultural and industrial development. This lack of fresh water may result from one of the two following causes:

(a) Insufficient total rainfall;

(b) Adequate total rainfall, but this occurring in comparatively short periods of heavy rain, separated by long periods of drought.

In areas where (a) applies, the only possible means of supplementing the scanty rainfall is likely to be the utilization of any supplies of brackish or salt water which may be available by the adoption of some method of demineralization. Where there is, however, adequate total rainfall, collection and storage of the rainwater is called for. This is most frequently achieved by building open reservoirs in suitable situations.

The two great sources of loss from open reservoirs are seepage and evaporation. Although work is now being carried out by the U.S. Department of Agriculture on the use of sheets of polyvinyl and polyethylene plastics to reduce seepage from small reservoirs, rather more practical experience is being accumulated of methods for the reduction of evaporation losses. This is of particular interest to tropical areas where the quantities of water which evaporate from lakes and reservoirs during hot dry spells may be very considerable. Thus, from water surfaces in the more populous (i.e., not the driest) areas of Kenya, between 5 ft. and 6 ft. depth of water is lost annually, and in the more arid regions such as parts of Tanganyika, Rhodesia and Somaliland, evaporation losses may amount to as much as 12 inches per month. The loss represented by 1 foot of evaporation over an acre surface is, in round figures, 270,000 Imperial Gallons, so that, in Kenya, where there are some 112 square miles of water surface in natural and artificial reservoirs, about $9{\cdot}7 \times 10^{10}$ gallons are lost each year by evaporation. It has been estimated that, in the state of Texas, $7\frac{1}{2}$ million acre-feet of water ($2{\cdot}0 \times 10^{12}$ Imperial Gallons) are lost each year by evaporation while, in the same period, the actual consumption of water is only 8 million acre-feet ($2{\cdot}2 \times 10^{12}$ Imperial Gallons). In certain tropical areas, sufficient rainfall to produce significant inflow into a reservoir may sometimes not occur for periods of as much as three years, and evaporation losses can be so great that reservoirs serve little useful purpose.

Reduction of evaporation can be achieved by a thick layer of an oily substance but it has been found that these oil films are easily broken up by dust and wind action. A more promising method depends on using

certain compounds such as hexadecanol (cetyl alcohol) which have both hydrophilic and hydrophobic portions to their molecule, whilst being almost insoluble in water. When placed on a water surface the forces of attraction between the component molecules and water are greater than those between the molecules themselves and, to acquire the position of least energy, the substance spreads out over the water until a monomolecular layer is achieved. The properties of films formed in this way differ according to the amount of lateral adhesion between the component molecules, and if this adhesion is great the film will behave almost as if it were a solid. In addition, the film should be formed from substances which interfere as little as possible with light and air absorption by the water, and which are non-toxic. Both hexa- and octadecanol are quite satisfactory in these respects.

Since Sir Eric Rideal showed in 1925 that surface films of this type retard evaporation, the phenomenon has received attention in various laboratories, but examination of their use under field conditions has been carried out only comparatively recently. Investigations concerning the practical use of these monomolecular films, or monolayers, are at present taking place in several countries including Australia, the United States, East Africa and Israel. W. W. Mansfield and his colleagues of the Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Melbourne, were the first to investigate the possibilities of using monolayers to reduce evaporation from large water surfaces. They found that the C_{16} and C_{18} long chain aliphatic alcohols provided the least permeable monolayers and their experiments have been carried out with hexadecanol (cetyl alcohol). This forms a liquid monolayer which, providing there is a reserve of solid material present, remains continuous despite the surface area of the water changing with variations in wind velocity; furthermore it seals itself again if it is broken by falling dust particles. It is important that the cetyl alcohol be free from impurities such as oleyl alcohol, since these spread rapidly to form relatively permeable monolayers.

In Australia several small scale tests have been carried out in evaporating vessels and the results of these were sufficiently encouraging for the investigations to be extended to larger stretches of water. The process has been recommended to the public for areas up to 2 acres on which waves are small and where there is little weed growth. Other techniques for use on larger areas are being studied. The basic idea is that the film is produced by and regenerated from solid cetyl alcohol contained in rafts floating on the surface of the water. Beads of cetyl alcohol about one-eighth of an inch in diameter are stored in gauze baskets which prevent them from dispersing but do not interfere with film formation. These are buoyed by floats, the whole raft taking many different forms. It is considered that one raft containing 2–2½ lb. of pellets is sufficient for areas of water up to one acre but that two should be used for areas between one and two acres. Details of the construction of rafts and their use are given in the C.S.I.R.O. leaflet No. 15 "Saving Water in Dams".

In some recent experiments in Australia the cetyl alcohol has been

applied in solution.* This method of application has also been tried by the East African Meteorological Department, Nairobi, who have found that beads of cetyl alcohol frequently become reduced in size by abrasion and escape from the rafts, or become covered with algae and silt.

Experiments in evaporating pans suggested that the film produced by placing drops of solution on the water surface was more effective than that generated from pellets of cetyl alcohol suspended in a gauze basket. However, as has been found in other investigations, the efficiency of a film deteriorates rapidly and a continuous supply of solution would probably be more satisfactory than the same amount of solution applied once or even twice daily. Some work has been carried out on small reservoirs in which the solution was applied manually twice a day or continuously by dosing tanks but further experiments on the efficiency and suitability of these two methods are required. It has been found that the wind, even a light breeze, has a great effect on the spreading of the film. If the solution is applied round the upwind perimeter of the reservoir, excess drops floating on the surface are carried downwind, dispersing as they reach new areas of water. A belt of comparatively calm water indicates the progress of the film. With the manual application of the solution, a dose of between $\frac{1}{2}$ and 1 litre per day per acre seems effective. Experience so far suggests that, with dosing by hand from a boat or the shore, it is practicable to establish and maintain a film of cetyl alcohol on reservoirs up to 1,000 yards long, in the direction of the prevailing wind. Application of solutions from below reservoir surfaces is also being examined.

It is difficult to calculate the efficiency of monolayers in reducing the rate of evaporation from reservoirs since, for example, the amount of water lost by seepage is unknown, but the theoretical reduction has been calculated by Mansfield. The presence of a monolayer of cetyl alcohol results in a total resistance which is three times greater than that provided by the laminar layer of air above a water surface out of doors and accordingly the natural evaporation should be reduced by about 70 per cent. However, any reduction in evaporation promotes an increased surface temperature and the consequent compensation reduces the efficiency of the film. It has been calculated, though, that a mean reduction of about 45 per cent should be obtained in normal summer conditions in inland southern Australia. Experiments in the cold season, and under very unfavourable conditions in Kenya, produced an apparent reduction of 20 per cent and in Tanganyika an estimated reduction of 30 per cent was obtained. The results of tests on a large reservoir in Australia are claimed to have shown a reduction of evaporation by 37 per cent. A satisfactory film of cetyl alcohol was maintained for more than three months despite exceptionally strong winds, and about one foot of evaporation was saved over an average area of 930 acres. Even higher reductions

* The solution used was made up of the following materials:—
1 litre of kerosene (illuminating paraffin)
30 g. cetyl alcohol
0·9 g. Pluronic F. 68.
The Pluronic F. 68 is a dispersing material made by the Wyandotte Chemicals Corporation of the U.S.A.

have been claimed in the United States using octadecanol rather than hexadecanol. The results from the Malya reservoir in Tanganyika have also shown a reduction in evaporation but the large amount of cetyl alcohol consumed needs an explanation. The answer will probably be found in various chemical and biological processes. Also the solubility of cetyl alcohol in water is unknown although it is generally held to be insoluble.

Until further work has been carried out on the technique and efficiency of reducing evaporation by the use of monolayers it is not possible to say exactly what the cost of the water saved will be, but, from provisional calculations which have been made by the Australian workers, it is suggested that, as a rough estimate, the raft process if used in Australia would be worth at least £4,000,000 per annum in water saved (see Appendix I).

Calculations made by the East African Meteorological Department have shown that a saving of approximately £850,000 per annum might be made by the use of monolayers on the 112 square miles of water in Kenya alone (see Appendix II).

Further work on this subject is contemplated by the C.S.I.R.O., Australia and by the East African Meteorological Department. In addition the Southwest Research Institute, Texas, is embarking on an extensive programme of research into the whole question, known as the Southwest Co-operative Research Project on Reservoir Evaporation Control, which is being sponsored by Texas organizations interested in water control. Because of the importance of this subject to many tropical countries the Tropical Products Institute is itself planning to embark on research into certain of the problems at present outstanding.

Note: The first international conference on "Reservoir Evaporation Control" was held in Texas on April 14th, 1956.

Appendix I

A satisfactory commercial raft will cost about £25 with an estimated useful life of 5 years. Hexadecanol to the required specification is expected to cost between 6*s.* and 7*s.* per lb. if purchased from the manufacturers. Assuming that 8 lb. of hexadecanol will be used each year for each acre treated and the retail cost of the alcohol is 10*s.* per lb., then the annual cost, excluding labour but including depreciation, is £9. The cost of the water saved, per acre, assuming a reduction of the evaporation by 25 per cent. will then be as in the table below:

Annual evaporation, *ft.*	Saving in *acre-ft.*	Cost per 1,000 gal. saved *pence*
2	0·5	16
3	0·75	11
4	1·0	8
5	1·25	6·5
6	1·5	5
7	1·75	4·5
8	2·0	4
9	2·25	3·5
10	2·5	3

Appendix II

Continuous dosing with cetyl alcohol solution at the rate of $\frac{1}{2}$ litre per acre per day during the six months of hot dry weather was assumed to reduce the evaporation losses of about 4 feet by 30 per cent. This is equivalent to 1·2 ft. depth of water and, for one acre, amounts to about 326,000 gallons. The cost of the solution and application per acre per day is:

	pence
$\frac{1}{2}$ litre paraffin (kerosene) . . .	4·0
15 g. cetyl alcohol at 2/6*d.* per lb. .	1·0
0·45 g. Pluronic F. 68 at 11/- per lb. . .	0·2
Labour and transport . . .	0·7
Total .	5·9

Cost per acre for 180 days (6 months) of dosing 1,062

$$\text{Cost per 1,000 gallons of water saved} = \frac{1{,}062}{326}$$

or approx. $3\frac{1}{4}d.$

Development of the technique may, of course, require the use of a more expensive substance than cetyl alcohol, but its greater permanence and, therefore, the smaller amount required would, in part at least, offset the extra cost.

This figure of $3\frac{1}{4}d.$ may be compared for example with the cost of collecting and storing water in reservoirs and dams in arid and semi-arid areas, which is normally taken as around 1/- per 1,000 gallons or, with the cost of water obtained by any of the known and explored methods of demineralizing saline water, e.g., distillation, ion exchange, electrodialysis, freezing or solvent recovery techniques. The most economical of these latter processes can only be expected with developments in hand to yield pure water at a cost of about seven shillings per 1,000 gallons.

The savings which could result from the use of monolayers on the 112 square miles of water in Kenya alone, may therefore be calculated as follows:

Assuming 326,000 gallons are saved per acre per annum, then the total volume saved would be $112 \times 640 \times 326{,}000$ gallons.

$$= 2{\cdot}3 \times 10^{10} \text{ gallons.}$$

The cost of this volume of water conserved by the use of monolayers would be:

$$\frac{£2{\cdot}3 \times 10^{10} \times 3\frac{1}{4}}{1{,}000 \times 240}$$

$$= \text{approx. } £300{,}000.$$

The corresponding figure if this volume of water were to be collected in new reservoirs—assuming of course that the extra rain water is available to be collected—would be:

$$\frac{£2{\cdot}3 \times 10^{10} \times 12}{1{,}000 \times 240}$$

$$= £1{,}150{,}000$$

References

"Influence of Thin Surface Films on the Evaporation of Water". By E. K. Rideal. *J. phys. Chem.*, 1925, **29**, 1585.

"The Effect of Surface Films on the Evaporation of Water". By W. W. Mansfield. *Nature*, Lond. 1953, **172**, 1101.

"Influence of Monolayers on the Natural Rate of Evaporation of Water". By W. W. Mansfield. *Nature*, Lond. 1955, **175**, 247.

Proceedings of the First International Conference on Reservoir Evaporation Control, San Antonio, Texas, 1956.

"Saving Water in Dams". C.S.I.R.O. Leaflet No. 15. Melbourne, 1956.

"Reduction of Evaporation from Reservoirs". By F. Grundy. Paper presented at 2nd International Conference on Surface Activity, London, April, 1957.

"Economic Methods of Controlling Evaporation of Water". By K. L. Sutherland (of C.S.I.R.O., Melbourne). *Research*, Lond., 1957, **10**, 198.

"Film protects climate's prey". *Chem. Engng News*, 1958, **36**, No. 26, 44.

Notes

Kola Nuts.—The following information regarding Kola nuts was recently furnished to an inquirer who was considering the production of extracts from the nuts. Such extracts form the basis of Kola-type soft drinks, and are also employed to a limited extent in pharmacy.

Among the natives of West Africa and the Sudan the chewing of Kola is general, the nuts, on account of their caffeine content, acting as a stimulant in the same way as tea and coffee.

Growing Areas. The trees, of which a number of species exist, are natives of West Africa, occurring from Sierra Leone eastwards as far as the Cameroons, Gabon and the Congo. Distribution has been widened by planting and cultivation within various territories. Introductions have also been made into South and Central America, the West Indies, Ceylon and Malaya but, generally, growing has not been on such a large scale as in West Africa.

Species. At least twenty-five species of the genus *Cola* have been reported, but only six or seven of these have been recognized as yielding nuts entering into commerce. Of these six, *C. nitida* (Vent.) Schott and Endl. (*C. vera* K. Schum.) and *C. acuminata* (Pal. de Beauv.) Schott and Endl. are the main and preferred sources of nuts. Other species of lesser importance, which are occasionally utilized, are *C. verticillata*, *C. anomala*, *C. ballayi*, *C. sphaerocarpa* and *C. astrophora*. Some disagreement on nomenclature exists and it is possible that certain of these species are not distinct but are varieties.

C. nitida is the most popular and widely grown species. It is a native of the forest zones of Sierra Leone and the Ivory and Gold Coasts, and is now cultivated in those regions and in Nigeria. Large tracts of lands near Lagos, and in the provinces of Ijebu, Abeokuta, Ibadan and Ondo are now given over to the trees. In the main, growing of this species is confined to the lowland rain-forest zones, and ends where the forest gives way to savannah; however, small areas of growth do occur in the drier north in the so-called Bida Emirate, where there is wet land with a high water table. Several distinct varieties of this species have been recognized. This is the species grown almost exclusively in Jamaica.

C. acuminata. The natural habitat is from southern Nigeria to Gabon, and the species is stated to occur also in the Belgian Congo; the westerly range is less than that of *C. nitida.* This species has been introduced and naturalized in a number of regions from Liberia to Angola. Growing is now extensive in the Yoruba country of Nigeria, especially in the provinces of Oyo, Ondo and Ijebu. This Kola is the one most highly regarded by the Yoruba peoples and preferred by them for their social and religious customs.

C. verticillata. This also has a wide range in West Africa and is found, either indigenous or cultivated, in the Ivory Coast, the Ashanti forests, the south of Nigeria and the Northern Region, the Cameroons and Portuguese Congo. Although planted on a small scale over a wide area, this species cannot be regarded as of much economic importance, as the nuts are considered inferior and command lower prices; it appears, however, that the tree fruits between May and July, about three or four months earlier than does *C. nitida*, and nuts can thus be put on the market when the better Kola is scarce and expensive.

C. anomala. This species appears to be confined to the highlands of the Cameroons, in the Bamenda province and adjoining territory towards Dschang, at altitudes of 3,000-7,000 ft. It is the only edible *Cola* in this area and probably the only one that flourishes at such altitudes.

The remaining species are of much less importance and nuts from them only occasionally enter into trade. Little detailed information about the distribution of these species is available.

Types of Nuts. As mentioned above, the Kola nuts of commerce are derived principally from *C. nitida* and *C. acuminata*, the former being the more predominant and popular source.

Dried Kola nuts (seeds), as usually seen in the United Kingdom, consist of the kernels only of the seeds, sometimes entire, but more often separated into the two cotyledons in the case of *C. nitida*; nuts from *C. acuminata* have three to five cotyledons. Externally, the nuts have a dull dark brown or reddish brown colour; internally, they are somewhat paler. The colour of the seeds is, however, dependent on a number of factors. *C. nitida* is known to exist in several varieties, to which have been given names such as *alba*, *rubra*, *mixta*, and *pallida*; the chief differences lie in the colour and size of the seeds, and the varietal names are, of course, descriptive of the former characteristic; *alba* is distinguished also by absence of red colour in the flower. However, it is possible to find nuts of different colour on the one tree and even in the same fruit, while occasionally a nut appears in which one cotyledon is pink or white and the other red. These differences can be traced to the genes carried by different trees; seeds on one tree can have different cotyledon colours if the flowers were fertilized by pollen from other varieties of tree. Pink colour is dominant to white, while red is dominant to both pink and white. Nuts from *C. acuminata* are pink or red, very occasionally white; those from *C. verticillata* are pink or red.

The treatment of the seeds also affects the final colour. In the fresh seeds, there is present an unstable kolatin-caffeine glycoside, but during drying an oxidase enzyme converts this glycoside into the characteristic kola red, the caffeine being liberated. If, however, the fresh seeds are boiled (or the enzyme otherwise inactivated) the dried seeds retain their original colour.

Nuts from *C. nitida* may contain up to 2·5 per cent. of caffeine; those from *C. acuminata* usually rather less, but normally above 1 per cent. Some of the other species contain little or no caffeine. In addition to caffeine and the substance kolatin already mentioned, there are present fat, sugar, much starch, traces of theobromine and catechins. It has not been possible, however, to trace detailed analyses of the various types of nuts.

Processing Methods. These are extremely simple. At picking, the seeds are covered with a tough white skin, and the first process is to remove this coat, usually by "sweating" the seed in heaps, by soaking, or by fermentation in broad leaves. Much of the kola grown in West Africa is for native use, and as the fresh nuts are required in this trade, packing for transport is done in baskets along with the leaves of the kola tree; in this way, with occasional re-moistening, the nuts can be kept fresh and free from mould for about a month. Nuts destined for export to Europe are sun-dried, the cotyledons usually becoming separated during the process.

Production and Availability. Large quantities of Kola nuts are grown in the various territories of West Africa, but a high proportion goes into the native trade, considerable amounts being carried northwards from the coastal producing zones to the great consuming areas of the Sudan region. Exact production figures are not available, but it is known that the railway from Lagos to Kano carries annually 60,000 tons of nuts, and it is estimated that with the quantities transported by other means or consumed locally, total Nigerian production must be of the order of 100,000 tons per annum. In the French territory of the Ivory Coast there are stated to be nearly 8½ million trees, from which an annual production of about 30,000 tons of nuts could be expected. Some recent figures for exports and imports of the nuts are given below, but it is doubtful if in all cases these give a complete picture of the production because of the extensive local consumption of the nuts in certain areas and native trade. However, it is clear that very large quantities of nuts are available in West Africa, and no doubt increased exports to this country could be arranged. As will be seen, the bulk of West Indian production goes to the U.S.A.

Exports of Kola Nuts from Producing Countries

Quantities in lb. with value in £ Sterling

Exporting Country	1954	1955	1956
Nigeria	(a)	696,750 *£13,861*	866,320 *£14,298*
Ghana (Gold Coast) (b)	10,590,720 *£272,982*	(a)	9,057,220 *£233,418*
Sierra Leone (c)	3,090,870 *£275,545*	2,524,030 *£212,095*	1,855,280 *£106,840*
Jamaica (d) (f)	(a)	1,050,460 *£23,442*	546,890 *£11,349*
St. Lucia (e)	(a)	3,880 *£206*	(a)

Notes

(a) Figures not available or not quoted.
(b) Main trade is overland to territories to north and east.
(c) About 95 per cent. of the exports are to Gambia.
(d) Over 97 per cent. of the exports are to U.S.A.
(e) Over 85 per cent. of the exports are to U.S.A.
(f) These figures differ somewhat from the imports into the U.S.A. quoted for Jamaica, but have been obtained from different sources.

Imports of Kola Nuts into the U.S.A. from Producing Countries

Quantities in lb. with value in $

Source	1955	1956
Jamaica (b)	958,010 *$62,022*	557,024 *$33,565*
Windward Islands	40,825 *$2,711*	19,750 *$1,195*
Ghana (Gold Coast)	103,120 *$4,848*	65,890 *$3,342*
Nigeria	347,400 *$14,674*	358,080 *$16,817*
Other British West Africa Territories	33,600 *$1,680*	33,610 *$1,680*
Liberia	(a)	22,400 *$705*
Algeria	11,300 *$509*	(a)
Total U.S.A. Imports	1,494,260 *$86,444*	1,056,750 *$57,304*

(a) Figures not available or not quoted.
(b) These figures differ somewhat from the exports quoted for Jamaica, but have been obtained from different sources.

No statistics for the imports of Kola nuts into the United Kingdom could be found, and the commodity is not listed separately in trade returns.

References

"The Useful Plants of West Tropical Africa". By J. M. Dalziel. London, Crown Agents for the Colonies, 1937.
"The Kola Nut of West Africa". By T. A. Russell. *World Crops*, 1955, **7**, 221/225.
"The Kola of Nigeria and the Cameroons". By T. A. Russell. *Tropical Agriculture*, 1955, **32**, 210/240. (This contains over 70 references to previous publications on Kola).

A.J.F.

Nutmegs from Zanzibar.—The nutmeg tree, *Myristica fragrans* Houtt., was introduced, with the clove tree, into Zanzibar at the beginning of the nineteenth century by an Arab of Mauritius or Réunion, and was established in the gardens of Arabs in Zanzibar. The Director of Agriculture, Zanzibar (*Department of Agriculture, Zanzibar, Bulletin No.* 1, 1958) states that trees of a considerable age are to be found there, generally associated with the older and larger clove plantations, and appear to have been planted by the wealthier Arabs. The number of trees growing in Zanzibar at present is probably only one or two hundred, more than half of which grow on private plantations. During more recent times very small quantities of nutmegs have been exported, but it is probable that the greater part of the crop is rarely harvested by the tree owners.

The scarcity of nutmegs and mace arising out of the damage caused by the Grenada hurricane of 1955 has focussed attention on the possibility of developing the production of these spices in Zanzibar, not only to take advantage of the very attractive prices at present obtainable, but also to provide the Protectorate with another industry, albeit a small one, to supplement its two main sources of income, cloves and coconuts. During 1957 local planters showed more interest in the crop and a few are reported to have carried out some planting.

A survey of the trees in Zanzibar has revealed a degree of variation in the size and shape of the nuts, and in the amount of mace carried in proportion to the nut. It is not known at present whether these variations reflect genetical differences, but the majority of the trees appear to bear nutmegs of substantially the same type, rather elongated and small.

Early in 1958, a small quantity of nutmegs was collected from trees growing on the Government estate at Kizimbani; one small group of trees, thought to be perhaps 50 years old, growing in a situation which was certainly not ideal, gave an average of 34 lb. of nutmegs per tree.

A sample of a few pounds of these nutmegs was examined at the Tropical Products Institute, and found to be similar in appearance to West Indian nutmegs but generally smaller. They were mostly oval in shape, but some were more or less elongated; about half were satisfactorily pale in colour, the remainder being distinctly darker. They varied from 0·7 to 1·1 in. in length and from 0·5 to 0·8 in. in breadth; the average count was about 140 to the pound. About one-eighth of the sample consisted of defective nuts, either broken, wormy or shrivelled.

Commercial opinions on the nutmegs were generally favourable. It was considered that, in view of the small size of the nutmegs, distributors would not consider sorting them, and they would be regarded as defectives, worth about 10/- or 10/6 per lb., for distillation purposes. Sound nuts, 130 to 140 to the pound, would be worth, say, 12/6 per lb. It was pointed out that, although prices might vary, and possibly fall to a low level, there was always a market for this type of nutmeg and growers should be sure, at least, of a fairly quick sale.

The bulk of the nutmegs collected at Kizimbani is being used for distillation trials; these are not yet completed, but present indications are that the oil is of the West Indian type. This work is being done in the distillery of the Clove Growers' Association, and, as the resources of the Association would no doubt be used for distillation of nutmegs on a commercial scale, Zanzibar should be able to export an oil of consistently high quality.

In view of the interest in the crop shown by growers, and anticipating a favourable outcome of the tests on the nutmegs, the Department of Agriculture planted many more seeds than usual at the end of 1957. Seedlings, however, are not very satisfactory planting material. The trees are dioecious; about fifty per cent of the seedlings develop into male trees, which do not bear fruit, and as only one male tree to every ten or twelve female trees is necessary to ensure pollination, the remainder must be destroyed. The sex of the tree cannot be determined until they commence to bear fruit, which takes about nine years. Vegetative propagation from female trees is thus very desirable, and the Department is actively investigating methods which have been used elsewhere with fair success.

E.B.

Mangrove Bark from Sarawak

By Miss H. Bennett and R. D. Coveney

Mangroves are found distributed widely throughout the tropics, extending from West and East Africa, through the Indian and Malayan regions to the Philippines and Formosa in the north, and to New Guinea and Northern Australia in the south.

The most extensive mangrove swamps of the Malay region are found in Borneo where stands of a relatively few single species occur together in a well-defined distribution, particularly at the mouths of some of the larger rivers.

In Sarawak the most useful products of the mangrove forests are timber, firewood, charcoal and the solid tannin extract prepared from the bark, commonly referred to as cutch. The bark is never exported as such and only a small amount is used as a tanning material by local fishermen. All the cutch prepared at the extract factory of the Sarawak Co. Ltd. is exported, there being no use for the cutch locally. The species of mangrove which are of interest as sources of tanning materials include *Rhizophora mucronata*, *R. conjugata*, *Bruguiera gymnorrhiza* and *B. eriopetala*; of these the first is considered the most valuable species and only trees of 24 in. circumference and over are generally used.

The samples of bark of *R. conjugata*, *B. gymnorrhiza* and *B. eriopetala*, which are the subject of this report, were forwarded to the Institute by the Conservator of Forests, Sarawak. The samples had been sent for tannin analysis to ascertain the relative value of each species and of the various sizes of tree from the point of view of forest management and the economics of the extract manufacturing industry.

Particulars of the samples were given as follows:

List of Bark Samples

1. *Bruguiera gymnorrhiza* Lamk. ('putut')

   Herbarium reference No.: S106
   Date of collection: 15th to 20th May, 1957.
   Locality: Rejang Delta; mostly from the Belawai River but some from the north bank of the Kaban channel.
   Method: Trees were felled and bark removed at a height of about 15 feet from the ground. When possible the bark was cut into slabs 48 in. × 12 in., but it was found that the bark of the smaller trees was difficult to remove, and broke easily.

Reference Nos.:

P1 to P10: samples from girth class 16—20 in.
P11 to P20: „ „ „ „ 20—24 in.
P21 to P30: „ „ „ „ 24—28 in.
P31 to P40: „ „ „ „ 28—32 in.
P41 to P50: „ „ „ „ 32—36 in.

Note: girth measured at height of 4 ft. 6 in. from ground.

2. *Rhizophora conjugata* L. ('bakau minyak')

Herbarium reference No.: S107
Date of collection: 16th to 18th April and 15th to 20th May, 1957.
Locality: Rejang Delta, all from the Luau channel near its junction with the Rejang.
Method: As for *Bruguiera gymnorrhiza*, but samples taken from a height of about 15 ft. above stilt roots.
Reference Nos.:

A1 to A10: samples from girth class 16—20 in.
A11 to A20: „ „ „ „ 20—24 in.
A21 to A30: „ „ „ „ 24—28 in.
A31 to A40: „ „ „ „ 28—32 in.
A41 to A50: „ „ „ „ 32—36 in.

Notes: (1) Girth measured immediately above stilt roots.
(2) This is the principal species used by the cutch factory at Selalang. 'Bakau kurap' (*R. mucronata*), which is generally considered superior, is not well represented in this locality, and no samples were taken.

3. *Bruguiera eriopetala* W. & A. ('Tumu' or 'berus')

Herbarium reference No.: S108
Date of collection: 15th to 20th May, 1957.
Locality: Rejang Delta, Luau channel.
Method: As for *B. gymnorrhiza*.
Reference Nos.:

B1 to B10: samples from girth class 16—20 in.
B11 to B20: „ „ „ „ 20—24 in.
B21 to B30: „ „ „ „ 24—28 in.

Notes: (1) Girths measured at 4 ft. 6 in. from ground.
(2) This species is generally considered inferior and is not at present used by the cutch factory.

4. *General notes.*

(1) All bark samples were taken to the cutch factory at Selalang (Rejang Delta), where the owners (the Sarawak Company Ltd.) dried them as rapidly as possible on a boiler before shipment.
(2) The samples were shipped by the Sarawak Co. Ltd. in two cases, by the 'Laertes', which sailed for London on 20th June, 1957.

Description of Samples

Bruguiera gymnorrhiza Lamk. ("P." samples)

The bark of this species was dark reddish-brown in colour with dark purplish patches. It was fairly heavily coated with outer bark which, in many cases, showed scattered white patches and moss on its surface. There were also characteristic, small, circular marks about $\frac{1}{8}$ to $\frac{1}{4}$ in. diameter on the outer bark of some samples. The bark was rough, fibrous and rather brittle. The samples varied in size from small chips up to pieces 4 ft. long.

Rhizophora conjugata L. ("A." samples)

In general the bark was light reddish-brown in colour and was not so heavily coated with outer bark as that of *Bruguiera gymnorrhiza*. Again, there was evidence of white patches together with a little moss on the outer bark of some samples. The inner bark of this species showed characteristic, deep, transverse grooves, which were more or less marked in all the samples. The bark was smooth, not very fibrous, but quite brittle. The samples varied in size from small chips up to pieces 3 ft. long.

Bruguiera eriopetala W. & A. ("B." samples)

The colour of these samples was similar to that of the *Rhizophora* barks, but slightly more purplish-red. The outer bark was also similar, but the inner bark only showed short, shallow, transverse grooves, in a few cases. The bark was fairly smooth, brittle and very fibrous. The samples varied in size from small chips up to pieces 4 ft. 6 in. long.

Sample B. 17, however, was atypical of this species. It had a smooth bark showing deep, transverse grooves, and was not very fibrous; all these features being more characteristic of the bark of *R. conjugata*.

In view of the considerable time that would be required to carry out analyses on all the samples submitted, it was decided to confine the examination to five of the ten samples from each girth class.

Portions representative of the bulk of each sample were withdrawn and prepared for analysis by chopping the bark into small pieces and grinding in a Christy and Norris mill to the required degree of fineness; the bark ground in this way required no further grinding.

Results of Examination

The analyses were made in accordance with the Official Methods of Analysis of the Society of Leather Trades' Chemists, 1957, using hide powder batch No. C.16 for samples P1, 5, 10, 11, 15, 20, 21, 30, 31, 40, 41, 45, A1, 5, 10 and hide powder batch No. C.19, for the remainder.

The Procter method of extraction was employed, and the tannin infusions were filtered, without the use of kaolin, before the determination of total solubles; the moisture contents were determined by direct drying. In the analyses carried out the gelatin-salt test showed that the tannin was completely absorbed by the hide powder in all cases.

In the case of the *Bruguiera eriopetala* samples, it was not practicable

to prepare an extract of the "Official" analytical strength in the apparatus specified, as very large quantities of material would have been required. However, in most cases, the concentration was only slightly below the minimum value required by the method and the results should not be seriously affected.

The value found for tannin content of a few samples (e.g., P13, P17 and P47) appeared to be atypical of the girth class and in these cases the analysis was repeated in order to confirm the result obtained. The tannin content of sample B.17, which was confirmed by a repeat determination, was found to be about twice that of any other sample of *B. eriopetala* examined. The result is so atypical of the species as a whole that, in view of the similarity of the bark to that of *R. conjugata*, it seems probable that, inadvertently, this sample was incorrectly labelled and should have been included with the *Rhizophora* barks. It was decided, therefore, to analyse a further sample from this girth class, sample B.18, in order to obtain results from five samples about which there could be little doubt as to the species from which they were derived.

The results of analysis of the individual samples are shown in Table I and the mean values for tannins, non-tannins, tannin/non-tannin ratio, the tannin content of solid extract assuming 20 per cent. moisture and the colour values of each girth class and species, are given in Tables II to VI. The variation of tannin content with girth size is represented graphically in Graphs 1 to 4. In the tables of results and graphs the values obtained for sample B.17, which are recorded separately in Table I, are replaced by those for sample B.18.

Remarks

When considering the analytical constants of the barks it must be remembered that a delay of about a year between the stripping of the bark and its analysis will have resulted in some loss of tannin. Furthermore, the "Official Methods of Analysis" tends to give a value for tannin content slightly lower than that actually present in a bark at the time of analysis. The figures for tannin content recorded in this report will, therefore, be somewhat low, but, as relative differences between samples will be little affected, valid conclusions of a comparative nature may be drawn from the analyses.

Nevertheless, despite the preceding remarks, it will be apparent from Tables I and II that, in general, the tannin content of the three species (mean values, *Bruguiera gymnorrhiza* 16·3 per cent., *Rhizophora conjugata* 15·1 per cent. and *Bruguiera eriopetala* 7·2 per cent.), must be considered somewhat low as far as mangrove barks are concerned, particularly that of *Bruguiera eriopetala*.

Howes ("Vegetable Tanning Materials", Butterworths Scientific Publications, London 1953), states that the tannin present in mangrove barks of different kinds may vary from less than 10 per cent. to over 40 per cent., and that bark for export should have not less than 30 per cent. tannin. (Mangrove bark exported from East Africa is guaranteed to contain at least 37 per cent. tannin). In a sub-section on Borneo, Howes gives the tannin content for the most important species as:

1. *Rhizophora candelaria*, (=*R. conjugata*), "bakau" or "bankita", 25–30 per cent. tannin.
2. *Rhizophora mucronata*, "bakau" or "taggai", 25–30 per cent. tannin.
3. *Ceriops candolleana*, (=*C. tagal*), "tengah", 25–35 per cent. tannin.
4. *Bruguiera gymnorrhiza*, "lenggadi" or "pututan", 25–30 per cent. tannin.

The relatively low tannin content of the present samples, which is reflected in a correspondingly high content of insoluble matter, will militate against the shipping of bark for export and favour the production of extracts at source.

It will be observed from Tables I and II and the Graphs 1 to 4 that, in general, the tannin contents of *B. gymnorrhiza* and *R. conjugata* show a small increase with increasing girth size. The variation shown by *B. eriopetala* in this respect is too small to be significant. The tannin content of the first two girth classes (16 in. to 20 in. and 20 in. to 24 in.) of *B. gymnorrhiza* is, on the average, about 3 per cent. higher than that of *R. conjugata*, but the tannin contents of the three largest girth classes (24 in. to 28 in., 28 in. to 32 in. and 32 in. to 36 in.) of both species are almost identical.

The moisture content of all three species is fairly constant, falling within the range 7·5 to 10·6 per cent.; to some extent the variations in moisture content will have resulted from the different times at which samples were analyzed.

From Tables I and III it will be seen that the soluble non-tannin content of *B. gymnorrhiza* (mean value 7·5 per cent.) is slightly lower than that of *B. eriopetala* (mean value 8·7 per cent.), but that of *R. conjugata* barks (mean value 13·0 per cent.) is, on the average, considerably higher. In none of the species is there any significant correlation between soluble non-tannins and girth size.

Although the mean tannin contents of the barks of *B. gymnorrhiza* and *R. conjugata* are of the same order, the higher soluble non-tannin content of *R. conjugata* is responsible for an important difference between these two species when comparing tannin/non-tannin ratios. It will be noted from Table IV that the mean value for the tannin/non-tannin ratio of *B. gymnorrhiza* is 2·2, whereas that for *R. conjugata* is only 1·2. For practical purposes in tannin extract manufacture it is necessary that the tannin/non-tannin ratio be more than 1, and preferably over 2. It will be apparent, therefore, that, in relation to extract manufacture, the bark of *B. gymnorrhiza* is to be preferred to that of *R. conjugata*, and that of *B. eriopetala* (mean tannin/non-tannin ratio 0·8) would in all probability prove uneconomic in this respect. The relationship between tannin/non-tannin ratio and girth size is similar to that for tannin content in that there is, in general, a small increase in this ratio with increasing girth size.

The mean tannin content of solid extracts from each of the three species, which have been calculated from the tannin/non-tannin ratios assuming 20 per cent. moisture in the extracts, are shown in Table V. It will be observed that an extract of this type for *B. gymnorrhiza* is about 12 per cent. richer in tannin than that for *R. conjugata*. Howes states that most solid tannin extracts contain from 60 to 70 per cent. tannin and the

average tannin content of solid mangrove extracts is probably about 65 per cent.; it is apparent from Table V that the tannin content of a solid extract prepared from *B. gymnorrhiza* (mean value 54·8 per cent. tannin) is the only one to approach this value.

The colour of mangrove bark extracts is important in so far as it is the deep red colour imparted to tanned leather which is one of the main disadvantages of mangrove tannage. The values for Lovibond red units recorded in Tables I and VI for *B. gymnorrhiza* (mean value 9·9) may be considered satisfactory, but those of *R. conjugata* (mean value 13·0) and *B. eriopetala* (mean value 17·3), although not excessive, would be less acceptable, particularly those of *B. eriopetala*. There would appear to be no marked trends in the variation of colour with girth size, with the exception of the red units of the two largest girth classes of *R. conjugata* which show a marked decrease in this respect.

Summary and Conclusions

Analysis of the barks of a series of girth sizes of *Bruguiera gymnorrhiza*, *Rhizophora conjugata* and *Bruguiera eriopetala* from Sarawak has shown that the tannin contents, particularly that of *B. eriopetala*, are poor in relation to mangrove bark in general.

The barks of *B. gymnorrhiza* and *R. conjugata* exhibit a marked tendency, over the range of girth size examined, for the tannin content and the tannin/non-tannin ratio to increase with increasing girth size.

In view of the low tannin content of all three species, the export of bark as a commercial proposition cannot be recommended.

Suggestions for the possibilities of manufacturing extracts from each of the species are as follows:

Bruguiera gymnorrhiza

Of the three species examined this is undoubtedly the most valuable. Although the tannin content is similar to that of *R. conjugata*, the lower non-tannin content gives a tannin/non-tannin ratio of just over 2 which is about double that for the *R. conjugata* barks.

A solid extract prepared from this species, assuming 20 per cent. moisture, would contain approximately 55 per cent. tannin, a value which may be considered satisfactory in relation to the economics of extract manufacture; furthermore, the colour of the extract is also considered to be satisfactory.

In view of the increase of both tannins and the tannin/non-tannin ratio with girth size, over the range examined for this species, it is suggested that bark should be stripped progressively from the largest trees downwards and, in the first instance, stripping should be confined to the four largest girth classes (i.e., trees of 20 in. circumference and over).

Rhizophora conjugata

The lower tannin/non-tannin ratio (about 1) and poorer colour of the extract from this species renders it inferior to *B. gymnorrhiza*, and it is doubtful whether an extract containing approximately 43 per cent. tannins, assuming 20 per cent. moisture, would prove economic in

relation to extract manufacture. Only the availability of other raw materials and the prevailing circumstances of the extract industry could determine this.

If the bark is to be used, stripping should proceed in a manner similar to that described for *B. gymnorrhiza* but, in the first instance, it should be confined to only the three largest girth classes examined (i.e., trees of 24 in. circumference and over).

Bruguiera eriopetala

The tannin content of this bark and the colour of its extract are very poor and the ratio of tannins to non-tannins less than 1. Bark from this species is, therefore, considered unsuitable for extract manufacture.

Table I

Analytical Constants of Mangrove Bark Samples from Sarawak

Bruguiera gymnorrhiza Lamk. (P. samples)

	Girth Class 16—20 in.					Girth Class 20—24 in.					Girth Class 24—28 in.					Girth Class 28—32 in.					Girth Class 32—36 in.				
Sample No.:	1	3	5	7	10	11	13	15	17	20	21	23	25	27	30	31	33	35	37	40	41	43	45	47	50
Moisture, per cent. . .	10·1	9·7	10·5	9·1	10·6	10·2	9·4	10·2	9·6	10·0	10·2	9·1	10·5	9·0	9·9	10·8	8·1	9·8	8·6	10·5	10·3	8·6	9·5	7·5	10·3
Insoluble matter, per cent.	71·7	67·9	68·1	67·9	68·7	68·6	63·5	67·1	64·2	69·5	65·7	66·1	63·7	68·3	67·6	65·2	67·6	63·6	65·4	66·8	65·4	64·4	65·5	72·6	60·1
Soluble Non-Tannins, per cent.	7·0	7·7	7·0	8·4	7·1	6·8	7·8	7·8	7·6	7·0	8·2	9·0	6·7	8·1	7·6	6·7	7·5	7·6	8·1	7·4	6·1	8·3	7·6	7·5	6·6
Tannins, per cent. . .	11·2	14·7	14·4	14·6	13·6	14·4	19·3	14·9	18·6	13·5	15·9	15·8	19·1	14·6	14·9	17·3	16·8	19·0	17·9	15·3	18·2	18·7	17·4	13·4	23·0
Total soluble matter, per cent.	18·2	22·4	21·4	23·0	20·7	21·2	27·1	22·7	26·2	20·5	24·1	24·8	25·8	22·7	22·5	24·0	24·3	26·6	26·0	22·7	24·3	27·0	25·0	20·9	29·6
Tannin/Non-Tannin ratio	1·6	1·9	2·1	1·7	1·9	2·1	2·5	1·9	2·4	1·9	1·9	1·8	2·9	1·8	2·0	2·6	2·2	2·5	2·2	2·1	3·0	2·3	2·3	1·8	3·5
Tintometer readings corrected to an 0·5 per cent. tannin solution in a 1 cm. cell . . — Red Units	12·8	8·7	8·9	8·6	10·3	12·2	8·0	9·9	9·6	8·2	10·9	11·2	9·9	8·8	8·2	11·2	9·0	9·4	13·6	10·4	10·4	8·8	10·4	10·3	8·0
Tintometer readings corrected to an 0·5 per cent. tannin solution in a 1 cm. cell . . — Yellow Units	40·0	29·0	34·5	32·5	34·4	40·4	29·6	42·0	38·4	38·8	45·1	39·4	33·8	34·2	29·5	29·9	29·7	37·9	38·5	43·9	45·2	31·8	45·5	41·1	28·0

Rhizophora conjugata L. (A. samples)

Moisture, per cent. . .	8·7	7·8	9·2	7·5	8·4	10·4	9·2	10·8	8·9	10·6	9·5	9·0	9·9	8·9	8·7	9·6	8·7	10·3	8·3	10·0	9·1	8·8	9·2	8·8	8·9
Insoluble matter, per cent.	68·9	70·0	65·2	68·6	65·4	62·6	66·8	64·1	65·0	62·8	59·9	60·5	62·9	62·4	62·6	60·7	60·5	59·6	62·7	59·4	59·0	64·2	58·4	58·8	57·4
Soluble Non-Tannins, per cent.	12·9	12·6	13·4	13·7	13·6	12·6	11·3	12·4	14·2	12·1	11·6	13·2	11·9	15·8	14·4	14·5	13·1	11·6	14·7	12·7	11·9	11·9	12·0	12·4	15·6
Tannins, per cent. . .	9·5	9·6	12·2	10·2	12·6	15·0	12·7	12·7	11·9	14·5	19·0	17·3	15·3	12·9	14·3	15·2	17·7	18·5	14·3	17·9	20·0	15·1	20·4	20·0	18·1
Total soluble matter, per cent.	22·4	22·2	25·6	23·9	26·2	27·6	24·0	25·1	26·1	26·6	30·6	30·5	27·2	28·7	28·7	29·7	30·8	30·1	29·0	30·6	31·9	27·0	32·4	32·4	33·7
Tannin/Non-Tannin ratio	0·7	0·8	0·9	0·7	0·9	1·2	1·1	1·0	0·8	1·2	1·6	1·3	1·3	0·8	1·0	1·0	1·4	1·6	1·0	1·4	1·7	1·3	1·7	1·6	1·2
Tintometer readings corrected to an 0·5 per cent. tannin solution in a 1 cm. cell . . — Red Units	14·5	16·9	18·5	13·7	19·0	12·8	13·3	14·8	16·4	17·4	11·7	14·5	15·2	12·9	16·3	10·6	7·6	7·2	11·4	9·7	8·7	10·8	9·8	10·5	10·1
Tintometer readings corrected to an 0·5 per cent. tannin solution in a 1 cm. cell . . — Yellow Units	42·5	49·4	64·8	41·5	50·1	46·4	43·6	52·3	55·3	63·5	35·4	45·3	46·1	67·0	43·9	52·5	39·3	25·3	44·8	40·6	42·8	56·3	39·3	45·5	42·7

TABLE I—*continued*

Bruguiera eriopetala W. & A. (B. samples)

Sample No.:	Girth Class 16—20 in.					Girth Class 20—24 in.					Girth Class 24—28 in.						
	1	3	5	7	10	11	13	15	18	20	21	23	25	27	30		
Moisture, per cent. . .	9·9	8·5	9·6	8·2	9·3	8·6	8·2	8·6	8·5	8·6	8·6	8·6	8·9	8·7	8·6	8·8	Values found for Sample B.17.
Insoluble matter, per cent.	73·4	74·1	73·0	76·6	75·9	77·4	74·8	75·0	74·1	77·3	75·0	75·4	76·3	75·6	74·7	60·4	
Soluble Non-Tannins, per cent.	8·4	9·6	9·4	9·3	8·3	8·0	9·3	9·9	9·4	7·6	9·2	8·7	7·7	8·7	7·4	14·0	
Tannins, per cent. . .	8·3	7·8	8·0	5·9	6·5	6·0	7·7	6·5	6·8	6·5	7·2	7·3	7·1	7·0	9·3	16·8	
Total soluble matter, per cent.	16·7	17·4	17·4	15·2	14·8	14·0	17·0	16·4	16·2	14·1	16·4	16·0	14·8	15·7	16·7	30·8	
Tannin/Non-Tannin ratio	1·0	0·8	0·9	0·6	0·8	0·8	0·8	0·7	0·7	0·9	0·8	0·8	0·9	0·8	1·3	1·2	
Tintometer readings corrected to an 0·5 per cent. tannin solution in a 1 cm. cell . . — Red Units	16·1	16·9	16·1	16·6	14·1	19·2	17·0	18·8	18·2	18·0	16·7	19·1	16·1	18·5	17·5	17·9	
Tintometer readings corrected to an 0·5 per cent. tannin solution in a 1 cm. cell . . — Yellow Units	56·3	48·6	49·7	63·0	58·9	56·8	50·9	44·2	49·2	48·4	52·3	47·1	51·8	50·2	39·8	44·5	

Tables of Mean Values for each Girth Class and Species

(Excluding values found for Sample B.17)

Table II

Tannins, per cent.

Girth Class (*inches*)	*B. gymnorrhiza*	*R. conjugata*	*B. eriopetala*
16—20	13·7	10·8	7·3
20—24	16·1	13·4	6·7
24—28	16·1	15·8	7·6
28—32	17·3	16·7	—
32—36	18·1	18·7	—
Mean for Species	16·3	15·1	7·2

Table III

Soluble Non-Tannins, per cent.

Girth Class (*inches*)	*B. gymnorrhiza*	*R. conjugata*	*B. eriopetala*
16—20	7·4	13·2	9·0
20—24	7·4	12·5	8·8
24—28	7·9	13·4	8·3
28—32	7·5	13·3	—
32—36	7·2	12·8	—
Mean for Species	7·5	13·0	8·7

Table IV

Tannin/Non-Tannin Ratio

Girth Class (*inches*)	*B. gymnorrhiza*	*R. conjugata*	*B. eriopetala*
16—20	1·8	0·8	0·8
20—24	2·2	1·1	0·8
24—28	2·1	1·2	0·9
28—32	2·3	1·3	—
32—36	2·6	1·5	—
Mean for Species	2·2	1·2	0·8

TABLE V

TANNIN CONTENT OF SOLID EXTRACTS ASSUMING 20 PER CENT. MOISTURE CONTENT.

Girth Class (*inches*)	*B. gymnorrhiza* *per cent.*	*R. conjugata* *per cent.*	*B. eriopetala* *per cent.*
16—20	51·4	35·6	35·6
20—24	55·0	41·9	35·6
24—28	54·2	43·6	37·9
28—32	55·8	45·2	—
32—36	57·8	48·0	—
Mean for Species	54·8	42·9	36·4

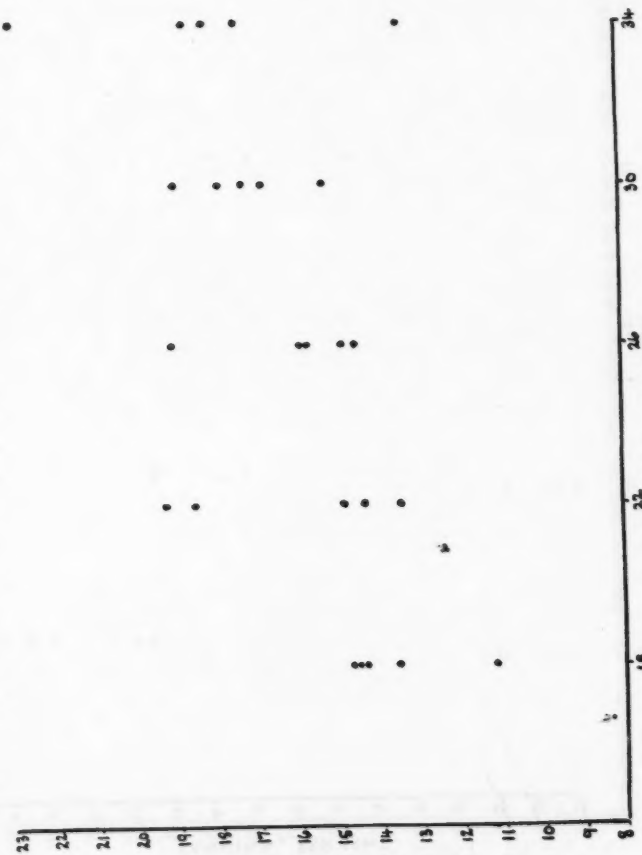
TABLE VI

COLOUR, LOVIBOND TINTOMETER UNITS

Girth Class (*inches*)	*B. gymnorrhiza*		*R. conjugata*		*B. eriopetala*	
	Red	Yellow	Red	Yellow	Red	Yellow
16—20	9·9	34·1	16·5	49·7	16·0	55·3
20—24	9·6	37·8	14·9	52·2	18·2	49·9
24—28	9·8	36·4	14·1	47·5	17·6	48·2
28—32	10·7	36·0	9·3	40·5	—	—
32—36	9·6	38·3	10·0	45·3	—	—
Mean for Species	9·9	36·5	13·0	47·0	17·3	51·1

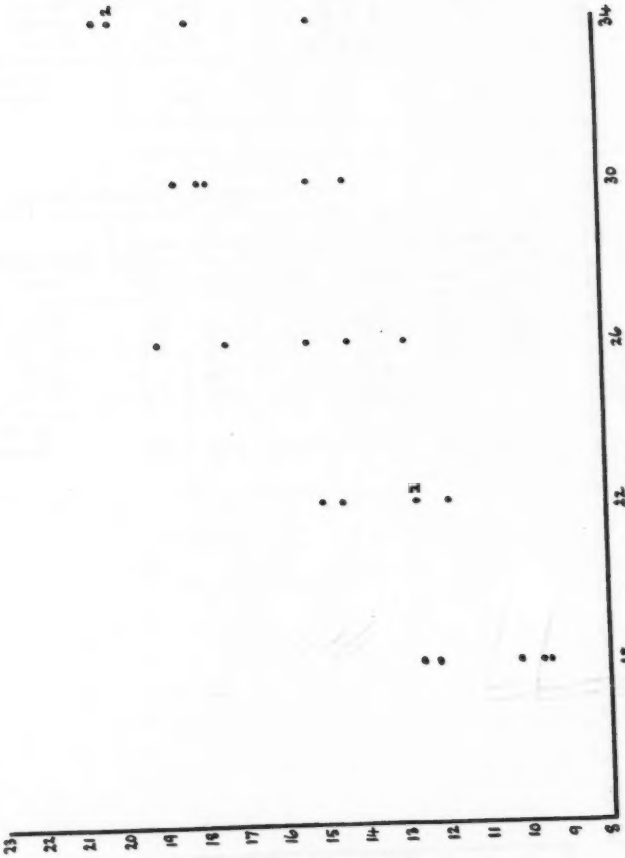
GRAPH 1

VARIATION OF TANNIN CONTENT WITH GIRTH SIZE FOR BRUGUIERA GYMNORRHIZA.



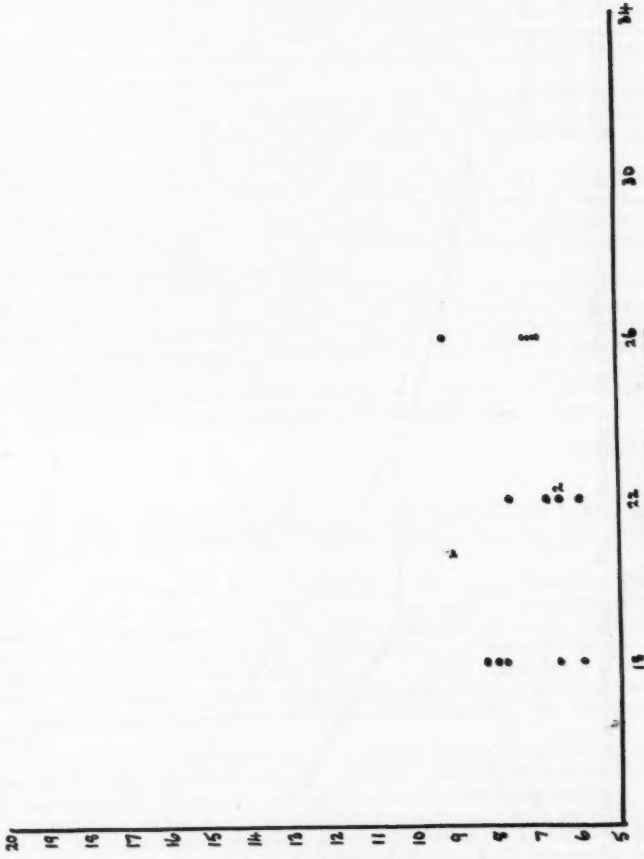
GRAPH 2

VARIATION OF TANNIN CONTENT WITH GIRTH SIZE FOR RHIZOPHORA CONJUGATA.



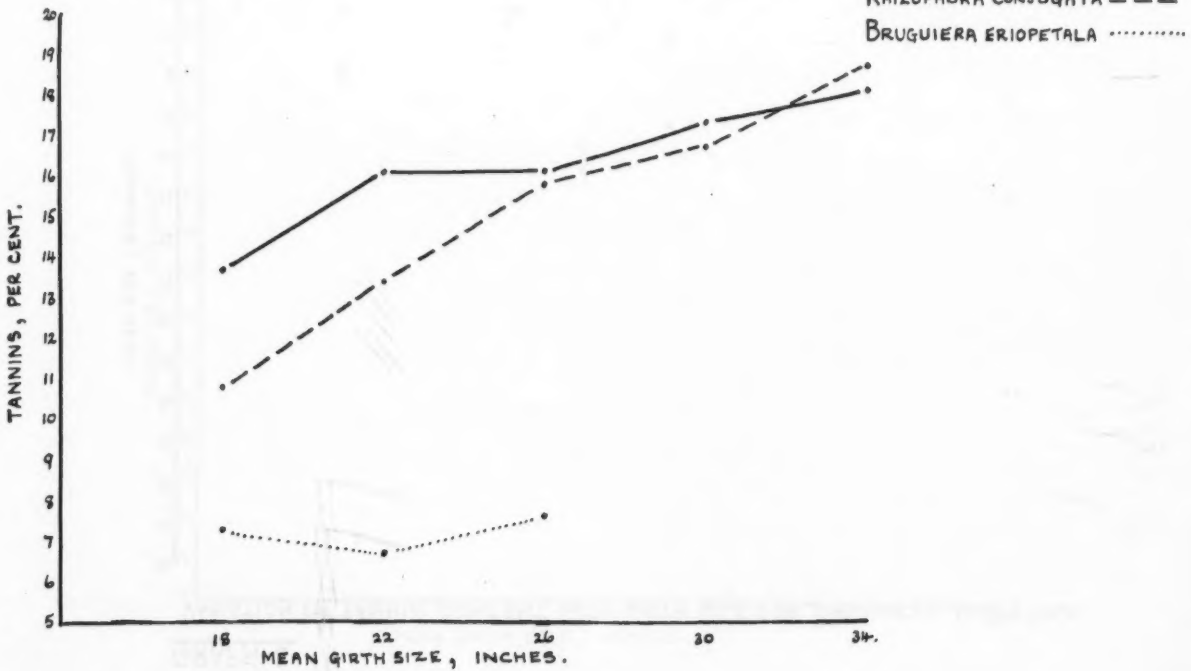
GRAPH 3

VARIATION OF TANNIN CONTENT WITH GIRTH SIZE FOR BRUGUIERA ERIOPETALA.



GRAPH 4

VARIATION OF MEAN TANNIN CONTENT WITH GIRTH SIZE FOR EACH GIRTH CLASS OF : BRUGUIERA GYMNORRHIZA ——— RHIZOPHORA CONJUGATA — — — BRUGUIERA ERIOPETALA .....



Book Reviews

THE MALTA DIRECTORY AND TRADE INDEX. 1958/59. 416 pp. 10 × 7½ (Valetta: Malta Publicity Services, Ltd., 1958). Price 25*s.* 6*d.*

The third annual edition of this book contains information similar to that in the previous editions, although there are now four parts instead of three. Part I contains an account of the background of Malta's industrial history and development and a brief description of each of its most important industries. One of the most interesting items in this part is the section devoted to the advertising media available in Malta and businessmen who are contemplating entering the Malta market should find this most valuable.

Part II is the Trade Index which contains an alphabetical list of firms and proprietary goods. In this edition, for the first time, parallel translations in French, Italian and German of the names of industries shown in the index are given. This should help to increase the value of the index considerably.

Part III of previous editions has now been divided into Part III, which deals with commerce and industry, and Part IV which is the Year Book Section. Part III contains tables of imports and exports, import and export duties, notes about the prohibitions and restrictions on imports and exports, and much other useful information relating to commerce and industry.

Part IV, the Year Book Section, includes information on the history of Malta and its Government, with a note about the present administration of Government, details of educational facilities, lists of persons engaged in professional occupations, and information of a general character likely to be of interest to tourists and other visitors to Malta.

The standard of production of this edition is up to that of the previous editions. Any firm interested in trade development in Malta should have a copy.

R.H.K.

ANNUAL REVIEW OF PLANT PHYSIOLOGY. 1958. **9.** Edited by A. S. Crafts. vi + 510 pp., 9 × 6¼ (Palo Alto, California: Annual Reviews, Inc., 1958). Price $7.50.

The subjects dealt with in this, the ninth volume of the Annual Review of Plant Physiology, follow the general pattern set in previous issues. The articles on the quantum yield of photosynthesis and on the metabolism of amino acids and proteins continue the practice, which has always been a feature of the review, of dealing with some aspect of current research in these major fields of plant physiology. A stimulating discussion of the interrelationships of nitrogen metabolism, respiration and carbohydrate metabolism is given by E. W. Yemm and B. F. Folkes.

The enormous volume of current research on growth-regulating substances is indicated by the fact that they form the subject of four of the articles in this volume, and have also been dealt with in each of the preceding volumes.

The usual article on plant enzymes is included, dealing in this instance with cytochromes. Secondary plant products are represented by flavonoids, the biogenesis of which is ably discussed by L. Bogorad. Economically important crop plants are dealt with in two articles, one on the physiology of the tobacco plant, and one on the mineral nutrition of tree crops. Of both academic and economic interest is the article on the post-harvest physiology of fruits.

A welcome departure in this volume is the attention given to lower plants in an article on the physiology of fresh water algae, and another on morphogenesis in bryophytes, algae, fungi, and slime moulds.

M.P.C.

SUGAR. By Hubert Edson. 224 pp., 8¾ × 6 (New York: Chemical Publishing Co. Inc., 1958). Price $5.00.

This book is largely autobiographical. The author spent sixty-two years in the sugar industry commencing as a bottle washer and ending as a consultant. A good deal of factual information is given about sugar cultivation and processing, and the period covers the transition from scarcity to surplus. An appendix written by A. E. Lewis deals very briefly with the technical processes involved in sugar manufacture. The story is doubtlessly a fascinating one to anyone intimately concerned with sugar production, but the title may be misleading although the book does not claim to be a technical treatise.

W.D.R.

ANNUAL REVIEW OF BIOCHEMISTRY, 1958, **27.** Editor, J. M. Luck. vii + 775 pp., 9 × 6½ (Palo Alto, California: Annual Reviews, Inc., 1958). Price $7.50.

The 27th volume of the Annual Review of Biochemistry follows the general pattern of this well-known series. The high reputation that these Reviews justly enjoy is ably maintained by the present volume.

The first of the 22 contributions is an interesting account by Professor H. T. Clarke of the growth of biochemistry within the last fifty years. It is indeed refreshing in an "Annual Review of Biochemistry" to find the opinion maintained that a thorough grounding in chemistry is the proper foundation for a study of biochemistry.

Advances in peptide chemistry are dealt with in chapters on protein biosynthesis, the biochemistry of the protein hormones, and amino acid metabolism. There is also a review of nutrition with special reference to protein malnutrition. Carbohydrates receive attention in two chapters. The first is a general account which contains a concise and interesting summary of conformational considerations of the pyranose ring: the second review is on carbohydrate metabolism. The reader finds that the vitamins are treated in the manner to which he has become accustomed, three chapters on the water-soluble vitamins and one on the fat-soluble vitamins.

Subjects dealing with aspects of enzymology are covered by contributions on the proteolytic enzymes, and on the enzymology of nucleic acids, purines, and pyrimidines. The important subject of biological oxidation receives attention in an article which covers photosynthesis, respiratory enzymes, oxygen metabolism, oxidative phosphorylation, and oxidases. Another review in this general category deals with recent enzymic studies on the metabolism of drugs and other foreign compounds.

Further subjects dealt with in this volume include the biochemistry of viruses and cancer; the chemistry and biochemistry of antibiotics; and the chemistry of fishes—the biblical plural is used. There is also an interesting account of the recent work on the biological synthesis of cholesterol and other steroids, with particular reference to the role played by mevalonic acid. Finally, as is becoming the custom, the volume includes a review of current biochemical studies in the U.S.S.R.

Each article in the volume is supplied with ample references which are collected at the conclusion of the chapter. In addition, there are comprehensive author and subject indexes at the end of the volume, and a helpful list of other reviews of biochemical interest which have appeared during the year.

E.M.T.

PERFUMES AND THEIR PRODUCTION. By E. S. Maurer. First Edition, 1958. viii + 320 pp., 6 × 9½ (United Trade Press Ltd.) Price 30*s*.

This book originated out of a series of articles entitled "The Essentials of Perfume Compounding", which appeared in the journal *Soap, Perfumery and Cosmetics*, for the year 1950 onwards; Part II of the book is based on these articles. Part I is "An Introduction to the Study and Handling of Perfumes" and provides a very good account of what happens in the process of making perfumes at the large

manufacturers. The author has clearly an intimate knowledge of his subject and his light, conversational style, even though a little precious at times, makes for easy reading.

Many of the older perfumers began with a training in pharmacy, and in Chapter 1 the author recommends this study as a good background for those wishing to take up perfumery as a career. Chapter 2 gives brief and practical "hints" about the handling of perfumery materials in the laboratory and is followed by a chapter on "Raw Materials, Purchases and Storage". Then there is an account of the compounding of perfumes in the essence room with a warning about the reactions likely to produce "hybrid odours" and a description of improvement by "ageing". An outline of the problems involved in the formulation of perfumes for soaps, cosmetics, etc., is given and Part I of the book concludes with a chapter on the subject of "Top Notes in Perfumery".

It is perhaps a little unfortunate that, whilst in the first section of the book free use has been made of formulations involving essential oils as such, Part II, which is the principal part of the book, deals only with isolates and synthetics, it being the author's intention to discuss the natural products in a later volume. This exclusion, although tending to a certain unbalance, allows a convenient treatment of the material under headings of the various chemical groups involved. The individual chapters dealing with methyl esters and formates, ethyl esters and acetates, and so on, usually set out the general properties of the group and conclude with a list of its particular constituents and a description of the odour and use of each.

Paragraphs from novels and travel books, the authors ranging from Oscar Wilde to Colette, and from Charles Darwin to Freya Stark, are placed at the end of various chapters throughout the book. All of these deal, from one aspect or another, with perfumes and odours, and, although such use of extracts in a work of a scientific nature often appears affected and obtrusive, in this instance they do not seem out of place.

G.B.P.

FLAVOR RESEARCH AND FOOD ACCEPTANCE. Sponsored by Arthur D. Little, Inc., vi + 391 pp., 9¼ × 6½. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958). Price $10.00.

This volume consists of a series of essays and topics concerned with food acceptance. Firstly, the physiological and psychological aspects are discussed in Part I (42 pages), followed by a section (Part II, 79 pages) devoted to laboratory flavour testing, where twelve papers are here presented dealing with such subjects as the application of statistics, method of scoring and the method of presentation of samples. Part III (59 pages) of the work deals with consumer reaction: it includes an important chapter on pilot consumer product testing. Under market testing and analysis we learn that conservatism in marketing does not pay. Over a given period of time conservatively-presented products secured only 11 per cent. increased sales as compared with 30 to 33 per cent. where changes of flavour or of "built-in conveniences" were incorporated into the product. Where the changes involved a lower price, the increased sales amounted to as much as 144 per cent; they could be 98 per cent even when the changes involved more expense to the consumer. Conversely, ringing changes too rapidly can lead to a loss in the identity of the product to the consumer, which is also damaging to sales.

Part IV (64 pages) discusses the specific application of various aspects of product testing in the development of special fields, such as those of the brewer, baker, canner and petroleum vendor. Finally, in Part V, some 120 pages are devoted to physico-chemical research methods. It is this portion of the volume which may be of most interest to scientists. The methods discussed are necessarily similar to those developed to detect and identify trace elements and involve operations such as concentration, distillation, fractionation, counter-current distribution, chromatography, mass and other forms of spectroscopy. Special applications of the techniques to particular problems such as the flavour of strawberries, the flavour of milk and milk products, and citrus flavours are

described. Flavour can be developed in a product due to enzymes; their action may be essential to full flavour development. These enzymes are often destroyed in the application of modern technology aimed at improving storage life, and the consumer may find such improved products relatively lacking in flavour.

The book is a useful collection of the views of various authorities concerned with different aspects of flavour research. Most food chemists will find the information of value, but the work should be of more interest to the manufacturer and those concerned with development.

W.D.R.

BOOKS RECEIVED FOR NOTICE

AMERICAN AGRICULTURE. By E. Higbee, x + 399 pp., 9¼ × 6¼ (London: Chapman and Hall, Ltd., New York: John Wiley & Sons Inc., 1958). Price 64*s.* net.

CONSERVATION OF NATURAL RESOURCES. Edited by G. H. Smith. xi + 474 pp., 9½ × 7 (London: Chapman and Hall, Ltd., New York: John Wiley & Sons Inc., 1958). Price 68*s.* net.

Bibliography

Compiled by Miss V. Clark.

Comprising the more important reports, articles, etc., contained in publications received in the Library during the year 1958.

*The publications issued by the Governments of the Colonies and Protectorates can be obtained from or through the Crown Agents for Overseas Governments and Administrations, 4 Millbank, Westminster, S.W.*1. *Applications for Dominion, Northern and Southern Rhodesian Government publications may be made to the Offices of the High Commissioners or Agents-General in London.*

Publications of the U.S. Departments of Agriculture and Commerce are obtainable from Superintendent of Documents, U.S. Government Printing Office, Washington 25, *D.C., U.S.A., or from H. M. Stationery Office, London.*

F.A.O. publications are obtainable from the Food and Agriculture Organisation of the United Nations, Washington 25, *D.C., U.S.A., or from H. M. Stationery Office, London.*

Agriculture

Report of the Agricultural Research Council for the Year 1956-57. 152 pp. (London: H. M. Staticnery Office, 1958). Price 7*s.*

Report, Colonial Development Corporation, 1957. 64 pp. (London: H. M. Stationery Office, 1958).

Colonial Research, 1956-1957. Reports of the Colonial Research Council, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Economic Research Committee, Colonial Fisheries Advisory Committee, Colonial Medical Research Committee, Colonial Pesticides Research Committee, Colonial Products Council, Colonial Road Research Committee, Colonial Social Science Research Council, Tsetse Fly and Trypanosomiasis Committee, Director, Anti-Locust Research Centre and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. *Cmnd* 321, 1957. 322 pp. (London: H. M. Stationery Office, 1957). Price 11*s.* net.

Report of the Rothamsted Experimental Station for 1957 (*with* 50-*year Index,* 1908-1957). 316 pp. (Harpenden, Herts.: Rothamsted Experimental Station, 1958). Price 10*s.* (post free).

Report of the East Malling Research Station, 1957. 173 pp. (Maidstone, Kent: East Malling Research Station, 1958). Price 17*s.* 6*d.* or $2.50 (post free).

Report of the Principal to the Governing Body, Wye College, for the Year 1956-57. 68 pp. (Ashford, Kent: Wye College, 1958).

Report, Glasshouse Crops Research Institute, 1956. 139 pp. (Littlehampton, Sussex: Glasshouse Crops Research Institute).

Report of the Department of Agriculture, Union of South Africa, for the Year 1956-7. 70 pp. (Pretoria: Government Printer, 1958). Price 10*s.* 9*d.*

Report, South African Council for Scientific and Industrial Research, 1956-1957. 210 pp. (Pretoria: Council for Scientific and Industrial Research).

Report, Department of Agriculture, Canada, for the Year ended March 31*st,* 1957. 159 pp. (Ottawa: Queen's Printer, 1957). Price 50 cents.

Report of the Prince Edward Island Department of Agriculture for the Fiscal Year ended March 31*st,* 1957. 109 pp. (Charlottetown: Department of Agriculture, 1957).

Report of the Department of Agriculture, Ceylon, for 1956. 91 pp. (Colombo: Government Publications Bureau, 1957). Price Rs. 2.30. Postage 35 cents.

Report of the Commonwealth Scientific and Industrial Research Organization, Australia, for the Year 1956-57. *No.* 54. 179 pp. (Canberra: Government Printer). Price 10*s.* 6*d.*

Report, Department of Agriculture, New South Wales, for the Year ended 30th June, 1957. 110 pp. (Sydney: Government Printer, 1958). Price 9*s*.

Report of the Bureau of Investigation, Department of Public Lands, Queensland, for the Year 1956. 19 pp. (Brisbane: Government Printer, 1957).

Report of the Department of Agriculture and Stock, Queensland, for the Year 1956-57. 123 pp. (Brisbane: Government Printer, 1957).

Report of the Department of Agriculture, Western Australia, for the Year ended 30th June, 1957. 50 pp. (Perth: Government Printer).

Report, Department of Agriculture, Falkland Islands, 1955 *and* 1956. 8 pp. Typescript copy. (Port Stanley: Department of Agriculture).

Report, Department of Agriculture, New Zealand, for the Year ended 31st March, 1958. 161 pp. (Wellington: Government Printer, 1958).

Report, Cawthron Institute for Scientific Research, 1956-1957. 53 pp. (Nelson, N.Z.: Cawthron Institute, 1957).

Report, East African Agriculture and Forestry Research Station (Institute), for the Period 1st July, 1956, *to 31st December*. 1957. 112 pp. (Nairobi: Government Printer, 1958). Price Sh. 3/50.

Report, East African Industrial Research Organization, 1956-1957. 8 pp. (Nairobi: Government Printer, 1957). Price Sh. 2.

Report, Department of Agriculture, Basutoland, for 1957. 71 pp. (Maseru: Director of Agriculture).

Report of the Cameroons Development Corporation for the Year 1956. 33 pp. (Bota, Victoria: Secretary, Cameroons Development Corporation).

Report of the Southern Cameroons Marketing Board, 1st October, 1956—*30th September*, 1957. 35 pp. (London: Crown Agents, 1958). Price 1*s*. 0*d*.

Report, Department of Agriculture, Kenya, 1956. *Volume II—Record of Investigations*. 181 pp. (Nairobi: Government Printer, 1958). Price Sh. 7/50.

Report, Department of Agriculture, Kenya, 1957. *Vol. I*. 56 pp. (Nairobi: Government Printer, 1958). Price Sh. 4.

Report of the Department of Agricultural Research, Federation of Nigeria, for the Year 1956-57. 48 pp. (Lagos: Federal Government Printer, 1958). Price 9*d*.

Report of the Department of Marketing and Exports, Federation of Nigeria, for the Year 1956-57. 20 pp. (Lagos: Federal Government Printer, 1957). Price 9*d*.

Report of the Agricultural Department, Eastern Region, Nigeria, 1955-56. 42 pp. (Enugu: Government Printer).

Report of the Eastern Regional Marketing Board, Nigeria, for the Period 1st January, 1956, *to 31st December*, 1956. 83 pp. (London: Crown Agents and Commissioner, Eastern Region). Price 2*s*. 6*d*.

Report of the Northern Region Development Corporation, Nigeria, 1957-1958. 76 pp. (Kaduna: Northern Region Development Corporation, 1958).

Report of the Western Region Marketing Board, Nigeria, 1st October, 1956, *to 30th September*, 1957. *Sess. Pap. No. 4 of* 1958. 70 pp. (Lagos and Ibadan: Department of Marketing and Exports, 1958).

Report, Department of Agriculture, Nyasaland, for the Year 1956-7. *Part II*. 142 pp. (Zomba: Government Printer, 1958). Price 6*s*. 6*d*.

Report, Department of Agriculture, Northern Rhodesia, 1957. 21 pp. (Lusaka: Government Printer, 1958). Price 2*s*. 6*d*.

Report of the Department of Agriculture, Sierra Leone, 1956. 31 pp. (Freetown: Government Bookshop, and Crown Agents). Price 3*s*.

Report, Department of Agriculture, Tanganyika Territory, 1956. *Part II*. 106 pp. 1957. *Part I*. 43 pp. (Dar es Salaam: Government Printer, 1958). Price Shs. 10/50 and 4/50.

Report and Accounts of the Tanganyika Agricultural Corporation for 1956-1957. 137 pp. (Dar es Salaam: Government Printer, 1958). Price Sh. 12/50.

Supplement to Report of Department of Agriculture, Zanzibar Protectorate, 1956. *Results of Field Experiments, Crop and Stock Records and other Statistics.* 12 pp. (Zanzibar: Government Printer, 1957). Price Sh. 1/50.

Report of the Department of Agriculture, Zanzibar, 1957. 37 pp. (Zanzibar: Government Printer, 1958). Price Shs. 2/-.

Report of the Department of Agriculture, Mauritius, 1955. *No.* 37 *of* 1957. 108 pp. (Port Louis: Government Printer, 1957). Price R. 1.25.

A Review of Agriculture and Forestry in the Island of St. Helena. By N. H. Obe. 88 pp. (St. Helena: Government Printing Office, 1957, and Crown Agents). Price 15*s.*

Report of the Department of Agriculture and Forestry, St. Helena, 1957. 21 pp. (Scotland: St. Helena: Department of Agriculture and Forestry).

Report of the Board of Agriculture, Bermuda, for the Year 1957. 15 pp. (Hamilton: Department of Agriculture).

Report on the Agricultural Department, Grenada, for the Year 1957. 57 pp. (St. George: Government Printer, 1958).

Report, Department of Agriculture, British Guiana, for the Year 1956. 66 pp. (Georgetown: " Daily Chronicle " Ltd., 1958).

Report, Department of Agriculture, British Honduras, for the Year 1956. 38 pp. (Belize: Government Printing Department).

Bulletin No. 55, *Department of Agriculture, Jamaica (New Series). Investigations,* 1955. 106 pp. (Kingston: Government Printer, 1957). Price 3*s* 6*d.*

Report on the Department of Agriculture, Jamaica, for the Year ended 31st December, 1956. 63 pp. (Kingston: Government Printer, 1958). Price 3*s.* 6*d.*

Report of the Governing Body and the Principal's Report, Imperial College of Tropical Agriculture, 1956-57. 63 pp. (St. Augustine, Trinidad: Imperial College of Tropical Agriculture, 1958).

Report, Department of Agriculture, North Borneo, for the Year 1956. By E. J. H. Berwick. 46 pp. (Jesselton: Government Printing Department, 1957).

Report of the Director of Agriculture, Cyprus, for 1956. *Annexure I. Report on the Extension Services.* By E. S. Porter and E. L. Drakos. 24 pp. (Nicosia: Department of Agriculture).

Report of the Director of Agriculture, Cyprus, 1956. *Annexure III. Horticulture.* By H. C. Ruck. 7 pp. (Nicosia: Department of Agriculture).

Report of the Director of Agriculture, Cyprus, for the Year 1957. By W. Allan. 67 pp. *Annexure II. Report of the Land Use Section for* 1957. By N. Macmillan. *Report on Agrarian Matters.* 1957. By D. Christodoulou. 18 pp. (Nicosia: Government Printing Office, 1958).

Departmental Reports, 1956-57, *Director of Agriculture, Fisheries and Forestry, Hong Kong.* 110 pp. (Java Road, Hong Kong: Government Printer, 1957). Price $4.

Report, Department of Agriculture, Fiji, 1957. *Coun. Pap. Fiji, No.* 18 *of* 1958. 17 pp. (*Suva: Government Press,* 1958). Price 2*s.*

Aperçu sur l'Économie Agricole de la Province du Kivu. *Publ. Dir. Agric., Royaume de Belgique.* 102 pp. (Brussels: Dir. Agric., 1957).

La Agricultura Chilena en El Quinquenio 1951-1955. 285 pp. (Santiago, Chile: Ministerio de Agricultura, 1957).

Yearbook of Agriculture, U.S. Department of Agriculture, 1958. 605 pp. (Washington D.C.: Superintendent of Documents, 1958). Price $2.25.

Saline Water Conversion Report for 1957. *Pbl. U.S. Dep. Interior.* 128 pp. (Washington 25, D.C.: Secretary, U.S. Department of the Interior, 1958).

Chemical Tranquilizer increases Crop Yield. *Agric. Chemic.,* 1958, **13,** No. 5, 48.

Golden Jubilee Issue. *Agron. J.*, 1957, **49**, No. 12, 611-694. Symposium of articles on agricultural research in U.S.

Report of the Florida Agricultural Experiment Station for the Fiscal Year ending June 30th, 1957. 397 pp. (Gainesville: University of Florida).

Proceedings of the Florida State Horticultural Society, 1956, **69**. 432 pp. (Stuart, Fla: Stuart Daily News, Inc.).

Economic Development and Planning in Asia and the Far East. The Agricultural Sector. *Publ. U.N. Econ. Bull. for Asia and the Far East*, 1957, **8**, No. 3. 106 pp. (London: H. M. Stationery Office, 1957). Price 3*s.* 9*d.*

The State of Food and Agriculture 1958. *Publ. F.A.O.* 222 pp. Price U.S. $2.50 or 12*s.* 6*d.* World review and outlook; statistics.

Report of the Agricultural Research Service, Jordan, for 1957. 60 pp. (Amman: Director of Agriculture, P.O. Box 226, 1958).

Beverages

Administration Report of the Cocoa Board, Trinidad and Tobago, for the Year 1956. 33 pp. (Trinidad: Government Printing Office, 1958). Price 70 cents.

Report, Coffee Research and Experimental Station, Lyamungu, Moshi, Tanganyika for the Season 1956-57. 14 pp. (Dar es Salaam: Coffee Research and Experimental Station, 1958).

La Conditionnement des Cafés à l'Exportation des Territoires d'Outre-Mer. By M. Piellard. *Rev. "Café, Cacao, Thé,"* 1958, **2**, No. 1, 15-33. Preparation of and specifications for coffee for export from the French Union.

Contribution a l'Étude des Déficiences Minérales du Caféier d'Arabie au Kivu. By J. P. Culot *et al. Publ. I. N. E. A C., Sér. sci. No.* 73, 1958. 105 pp. (Brussels: Institut National pour l'Étude Agronomique du Congo Belge, 1958). Price 120 francs.

Report, Department of Hop Research, South Eastern Agricultural College, Wye, 1957. 159 pp. (Ashford, Kent: Secretary, Wye College, 1958). Price 5*s.*

Proceedings of the Fourth Conference, Tea Research Institute of East Africa, 19th December, 1956. *Pamphlet No.* 13. 55 pp. (Nairobi: East African Standard Ltd., 1957). Papers on analysis, manuring and cultivation.

Bulletin No. 39, *Tea Research Institute of Ceylon. Report for the Year* 1957. 63 pp. (St. Coombs, Talawakelle: Tea Research Institute of Ceylon, 1958).

Report, Tea Scientific Department, United Planters' Association of Southern India; for 1957-1958, *and Bulletin No.* 18. *Proceedings of the Sixth Annual Conference*, 1958. 78 pp. (Coimbatore: United Planters' Association of Southern India, 1958).

Cereals

Investigations into Grain Storage Problems in Nyasaland with Special Reference to Maize (*Zea mays* L.). By K. F. Salmond. *Colon. Res. Publ. No.* 21. 49 pp. (London: H. M. Stationery Office, 1957). Price 4*s.* 6*d.*

Report, Maize Control Board, Southern Rhodesia, 1956-1957. 14 pp. (Lusaka: Maize Control Board, P.O. Box 122).

Mejoramiento del Maiz. (Improvement of Maize). *Proyecto Cooperativo Centro-americano. Segunda Reunion Centroamericana, Turrialba, Costa Rica, December 11th-15th*, 1955. 172 pp. (Turrialba: Instituto Interamericano de Ciencias Agrícolas).

Rice in India. By R. L. M. Ghose *et al. Publ. Indian Coun. agric. Res.* 507 pp. (New Delhi: Indian Council Agricultural Research, 1956). Price Rs. 21.00.

Report of the West African Rice Research Station, 1956. 38 pp. (Rokupr, Sierra Leone: West African Rice Research Station or Crown Agents, 1958). Price 2*s.*

Los Resultados de los Trabajos efectuados por la Estación Arrocera de Sueca

en al Año 1955. (Results of work done at the Rice Research Station of Sueca in the Year 1955). By J. de Oyanguren. *An. Inst. Nac. Invest. agron. Madrid*, 1957, **6**, No. 2, 73-223. Research on varieties, cultivation and preparation of rice.

Drugs

Travaux des Laboratoires de Matière Médicale et de Pharmacie Galénique de la Faculté de Pharmacie de Paris, 1957, **42**. (Paris: Vigot Frères, 1958). Papers on various drug plants including *Lochnera*, *Vinca*, *Tabernanthe*, *Drosera*, *Rauwolfia*, *Aloe* and *Catha* spp.

Bitter Principles of the *Cucurbitaceae*. VI—The Isolation and Characterization of Six New Crystalline Bitter Principles. By P. R. Enslin *et al.* VII—The Distribution of Bitter Principles in this Plant Family. By S. Rehn *et al.* VIII—Cucurbitacins in Seedlings—Occurrence, Biochemistry and Genetical Aspects. By S. Rehm and J. H. Wessels. *J. Sci. Fd Agric.*, 1957, **8**, No. 12, 673-678, 679-686, 687-691.

Symposium on *Rauwolfia*. By S. S. Bhatnager *et al. Indian J. Pharm.*, 1956, **18**; No. 4, 113-147; No. 5, 169-205; No. 6, 227-268; No. 7, 293-318; No. 11, 433-440. Papers on *R. serpentina*, *R. canescens* and *R. micrantha*. Cultivation and propagation, chemistry, botany, nomenclature, pharmacognosy, pharmacology, adulteration, standards.

Rauwolfia Alkaloids. *Research Today*, 1958, **14**, No. 1, 3-21. (Indianapolis 6: Lilly Research Laboratories, P.O. Box 814).

The Distribution of Alkaloids in *Rauwolfia caffra* sond. and Related spp. By W. E. Court *et al. J. Pharm. Lond.*, 1958, **10**, No. 6, 380-383.

Isolation of Serpentine from *Rauwolfia canescens* Root. By B. P. Ghosh. *Indian J. Pharm.*, 1958, **20**, No. 69-70.

Essential Oils

The *In Vitro* Antifungal Activity of Essential Oils. By J. C. Maruzella and L. Liguori. *J. Amer. pharm. Assoc., Sci. Ed.*, 1958, **47**, No. 4, 250-257.

The *In Vitro* Antibacterial Activity of Essential Oils and Oil Combinations. By J. C. Maruzella and P. A. Henry. *J. Amer. pharm. Assoc., Sci. Ed.*, 1958, **47**, No. 4, 294-296.

Recherches sur une Huile Essentielle d'*Eucalyptus dives* "Type" Originaire du Kivu. By Neirinckx and H. Struelens. *Publ. Dir. Agric. Royaume de Belgique*. 102 pp. (Brussels: Dir. Agric., 1958). Price 20 francs.

Fibres

Industrial Fibres. A Review of Production, Trade and Consumption relating to Cotton, Wool, Silk, Flax, Jute, Sisal and other Hemps, Mohair, Coir, Kapok, Rayon and Other Man-made Fibres. *Publ. Commonw. econ. Comm.*, 1958. 212 pp. (London: H. M. Stationery Office, 1958). Price 5*s*.

Report, British Cotton Growing Association for the Twelve Months ended 31st December, 1957. No. 187. 32 pp. (Manchester: British Cotton Growing Association, 1958).

Report, Empire Cotton Growing Corporation, 1958. 20 pp. (London: Empire Cotton Growing Corporation, 1958).

Report, Indian Central Cotton Committee, for the Year ended 31st August, 1957. 129 pp. (Bombay: Indian Central Cotton Committee, 1958). Price Rs. 3/-.

Progress Reports from Experiment Stations, Season 1956-57. *Northern Nigeria*. 22 pp. *Nyasaland*. 16 pp. *Republic of the Sudan*. 34 pp. *Tanganyika Territory, Eastern Province*. 15 pp. *Lake Province*. 24 pp. *Kenya*. 14 pp. *West Indies*. 10 pp. *Survey of Reports*. 12 pp. (London: Empire Cotton Growing Corporation, 1957 and 1958).

The Cotton Industry in a World Economy. Official Report on the International Cotton Conference held at Venice, Italy, from the 22nd to the 28th September, 1957. 286 pp. (Manchester: International Federation of Cotton and Allied Textile Industries, 1958).

Report, Indian Central Jute Committee. The Technological Research Scheme for 1956-57. 68 pp. (Calcutta: Indian Central Jute Committee, 1958).

Report and Accounts of the East African Sisal Industry comprising Tanganyika Sisal Growers' Association and Kenya Sisal Growers' Association for the Year ended 31st December, 1957, *and Estimates for* 1958. 67 pp. (Tanga: Tanganyika Sisal Growers' Association, P.O. Box 179, 1958).

Report of the Tanganyika Sisal Growers' Association for the Year 1957. 31 pp. (Tanga: Tanganyika Sisal Growers' Association, 1958).

Report, Wool Industries Research Association, for 1957-58. *Publ. No.* 211. 30 pp. (Leeds, 6: Wool Industries Research Association, 1958).

Fish and Fish Products

Governmental Services to the Sea-fish Industry of Great Britain. By F. M. G. Willson. *FAO Fisheries Study No.* 5, 1957. 127 pp. (London: H. M. Stationery Office, 1957). Price $1.25 or 6*s.* 3*d.*

Report of the Fishing Industry Research Institute, Cape Town, South Africa, 1st January, 1957—*31st December*, 1957. 54 pp. (Cape Town: Fishing Industry Research Institute, 1958).

Report of the Fisheries Department, Ghana, 1957. 15 pp. (Accra: Government Printer or Crown Agents, 1958). Price 2*s.* 6*d.*

Report, Fisheries Research Board, Canada, 1956-1957, *for the Fiscal Year ending March 31st*, 1957. 195 pp. (Ottawa: Queen's Printer, 1957).

Progress Report of the Atlantic Biological Station, St. Andrews, N.B. and the Fisheries Experimental Station (Atlantic) Halifax, N.S. No. 70. 34 pp. (Ottawa: Queen's Printer, 1958).

Progress Reports of the Atlantic Coast Stations, Fisheries Research Board of Canada, No. 69, 1958. 40 pp. (St. Andrews, N.B.: Director, Atlantic Biological Station, 1958).

Progress Reports of the Pacific Biological Station, Nanaimo, B.C., and Technological Station, Vancouver, B.C., No. 110 and *No.* 111, 1958. 18 pp. and 28 pp. (Ottawa: Queen's Printer, 1958).

Administration Report of the Director of Fisheries, Ceylon, for 1957. 31 pp. (Colombo: Government Publications Bureau, 1958). Price 80 cents. Postage 20 cents.

Report of the Operations of the Fisheries and Game Department, South Australia, for the Financial Year 1956-1957. 6 pp. (Adelaide: Government Printer, 1957).

Report, East African Fisheries Research Organization, 1956-1957. 45 pp. (Jinja, P.O. Box 343, Uganda: East African Fisheries Research Organization, 1958).

Report on Kenya Fisheries, 1957. 16 pp. (Nairobi: Government Printer, 1958). Price Sh. 2.

Report of the Federal Fisheries Service, Federation of Nigeria, for the Year 1956-57. 10 pp. (Lagos: Federal Government Printer, 1958). Price 9*d.* net.

Report of the Game and Fisheries Department, Uganda Protectorate, for the Period 1st July, 1956, *to 30th June*, 1957. 85 pp. (Entebbe, P.O. Box 33: Government Printer, 1958). Price Shs. 7/50.

Report, Lake Victoria Fisheries Service, 1956-57. 22 pp. (Kampala: Uganda Argus Ltd., 1957). Price Shs. 3/-.

2nd Symposium on African Hydrobiology and Inland Fisheries, Brazzaville, 1956. *Scientific Council for Africa South of the Sahara Publ. No.* 25. 268 pp. (London: Joint Secretariat C.C.T.A./C.S.A., 43, Parliament Street, S.W.1., 1957).

FODDERS

Report, Welsh Plant Breeding Station, 1950-1956. 171 pp. (Aberystwyth: University College of Wales, 1958). Price 7*s.* 6*d.*

The Aberystwyth Strains of Grasses and Clovers. *Leafl. Welsh Pl. Breed. Sta., No.* 6, 1958. 17 pp. (Aberystwyth: University College of Wales, 1958). Price 2*s.* 6*d.*

FOODSTUFFS

Dairy Produce. A Review of Production, Trade, Consumption and Prices relating to Butter, Cheese, Condensed Milk, Milk Powder, Casein, Eggs, Egg Products and Margarine. *Publ. Commonw. econ. Comm.* 130 pp. (London: H. M. Stationery Office, 1958). Price 5*s.* net.

Report, New South Wales Dairy Products Board, for the Year ended 30th June, 1957. 4 pp. (Sydney: Government Printer, 1957). Price 6*d.*

Report, British Society for the Promotion of Vegetable Research, 1957. 67 pp. (Wellesbourne, Warwick: National Vegetable Research Station, 1958).

FORESTRY

Report of the Forestry Commissioners for the Year ended 30th September, 1957. 90 pp. (London: H. M. Stationery Office, 1958). Price 5*s.* 6*d.* net.

Report, Imperial Forestry Institute, University of Oxford, 1956-57. 30 pp. (Oxford: Holywell Press Ltd., 1958).

Report of the Department of Lands and Forests of the Province of Alberta for the Fiscal Year ended March 31st, 1957. 98 pp. (Edmonton: Queen's Printer, 1957).

Administration Report of the Conservator of Forests, Ceylon, for 1957. *Part II—Revenue* (6). 48 pp. (Colombo: Government Publications Bureau, 1958). Price Rs. 1.20. Postage 35 cents.

Forest Research in India, 1954-55. *Part I. The Forest Research Institute.* 158 pp. 1952-53. *Part II. Reports from Burma and Indian States.* 153 pp. (Delhi: Manager of Publications, 1957). Price Part I Rs. 5.25 or 8 Sh. 3*d.* Part II Rs. 3.50 or 5 Sh. 6*d.*

Report on Forest Administration, Federation of Malaya, for the Year 1956. By D. S. P. Noakes. 103 pp. (Kuala Lumpur: Government Printer, 1957). Price $2.50.

Report of the Forest Service, Queensland, for the Year 1956-57. 54 pp. (Brisbane: Government Printer, 1957).

Report, Forests Commission, Victoria, 1956-57. 25 pp. (Melbourne: Government Printer, 1957). Price 1*s.* 9*d.*

Report of the Director of Forestry, New Zealand, 1st April to 31st March, 1958. 146 pp. (Wellington: Government Printer, 1958).

Report on the Forest Department, Eastern Region of Nigeria, 1957-58. 34 pp. (Enugu: Government Printer, 1958). Price 1*s.* 9*d.* net.

Report, Forestry Department (Administration), Northern Region of Nigeria, for the Year 1956-57. 39 pp. (Kaduna: Government Printer, 1958, or C.M.S. Bookshops). Price 9*d.*

Report on the Forest Administration of the Western Region of Nigeria for the Year 1955-56. *Sess. Pap. No.* 2, 1958. 34 pp. (Western Region, Nigeria: Government Printer, 1958). Price 1*s.*

Report of the Forest Department, Nyasaland, for the Year ended 31st December, 1957. 52 pp. (Zomba: Government Printer, 1958). Price 4*s.* 6*d.*

Report, Forest Department, Northern Rhodesia, for the Year 1957. 29 pp. (Lusaka: Government Printer, 1958). Price 2*s.* 6*d.*

Report, Forest Department, Tanganyika Territory, for the Year ended 31st December, 1957. 63 pp. (Dar es Salaam: Government Printer, 1958). Price Shs. 5/50.

Report of the Forest Department, Uganda, for the Year ended 31st December, 1957. 75 pp. (Entebbe: Government Printer, P.O. Box 33, 1958). Price Shs. 5.

Report of the Forest Administration in Cyprus for the Year 1957. 65 pp. (Nicosia: Government Printing Office, 1958).

Report of the Forest Department, Sarawak, for the Year 1957. By F. G. Browne and B. E. Smythies. 47 pp. (Kuching: Government Printer, 1958). Price $2 post free.

Report of the Department of Forestry, for the Year 1957. *Coun. Pap. Fiji, No.* 7. 20 pp. (Suva: Government Press). Price 2*s*.

Report, Southern Forest Experiment Station, 1957. 101 pp. (New Orleans: Southern Forest Experiment Station, 1958).

Fruit

Report, Fruit and Vegetable Preservation Research Station, Campden, 1956-57. 27 pp. (Chipping Campden: Fruit and Vegetable Preservation Research Station).

Report of the Agricultural and Horticultural Research Station, University of Bristol, Long Ashton, 1957. 181 pp. (Long Ashton, Bristol: National Fruit and Cider Institute, 1958).

California Fruit Statistics and Related Data. By S. W. Shear and R. E. Blair. *Bull. Calif. agric. Exp. Sta.*, 763, 1958. 269 pp. (Berkeley: California Agricultural Experiment Station, 1958).

The Market for Apples and Pears in O.E.E.C. Countries. *Publ. O.E.E.C.*, 1957. Price 3*s*.; $0.50; 150 Fr. francs.

Report of the Banana Board Research Department, Jamaica, 1956-1957. 22 pp. (Kingston: Banana Board Research Department, 1958).

Plantation d'Agrumes au Congo Belge. By J. Philippe. *Publ. Dir. Agric., Royaume de Belgique, Tract No.* 7. 32 pp. (Brussels: Dir. Agric., 1958). Price 10 francs. Practical hints on establishment and maintenance of citrus.

Citrus Industry of Chile. By J. H. Burke. *Foreign agric. Rep., No.* 108. 19 pp. (Washington 25, D.C.: U.S. Government Printing Office, 1958). Price 15 cents.

Studies on the Effect of Various Fungicides and Methods of Application that can be used in Citrus Packinghouses. By J. Du T. Deetlefs *et al. Citrus Gr.*, 1958, No. 290, 1-8.

Citrus Culture in Central Florida. By S. Ahmad. *Punjab Fr. J.*, 1957, **21,** No. 77, 21-24.

Handbook of Citrus Diseases in Florida. By L. C. Knorr *et al. Fla. Agr. Exp. Sta. Bul.* 587, 1957. 157 pp. (Gainesville: University of Florida, 1957).

The Grape. *International Fruit World*, 1958, **17,** No. 3, 3-45. (Basle, Switzerland: Oscar Bauer Publications, 1958). Article in English, French and German.

Commercial Guava Processing in Hawaii. By F. P. Boyle *et al. Bull. Hawaii agric. Exp. Sta. No.* 111, 1957. 30 pp.

Proceedings of the Florida Mango Forum. Seventeenth Annual Meeting, October 16th, 1957. 48 pp. (Miami: Secretary, Florida Mango Forum). Price $2.00.

The Pineapple in Malaya (*Ananas comosus* Merr.) By J. R. Dunsmore. *Malay. agric. J.*, 1957, **40,** No. 3, 159-187.

Pineapple in the Spotlight. *Int. Fruit World*, 1958, **17,** No. 2, 3-29. (Basle 2, Switzerland: Oscar Bauer Publications, 1958).

Influence of Transplant Type and Starter Solution on Tomato Yields in Trinidad. By J. S. Campbell. *Trop. Agriculture, Trin.*, 1958, **35,** No. 2, 134-144.

Gums

Guar: Its Development and Uses. By J. A. Esser. *Chemurg. Dig.*, 1958, **17,** No. 4, 9-12.

INSECTICIDES

Analyzing New Herbicides and Insecticides. By K. Gardner. *Chem. Prod.*, 1957, **20,** No. 5, 187-190.

Biological and Chemical Studies on the Decline of Soil Insecticides. By U. Kilgemagi *et al. J. econ. Ent.*, 1958, **51,** No. 2, 198-204. Rate of decline of aldrin, dieldrin and heptachlor measured.

The Control of Stored Grain Insects in South Africa. By B. Smit. 36 pp. *Bull. Dep. Agric. S. Afr., No.* 355, 1957. (Pretoria: Government Printer, 1957). Price 2*s.* 0*d.*

A Preliminary Investigation into the Insect Infestation of Cargoes from West Africa. By G. A. Matthews. *Ann. appl. Biol.*, 1958, **46,** No. 2, 259-263.

Report of the Colonial Pesticides Research Unit, Arusha, Tanganyika, East Africa, for 1957-1958. (*Progress Report No.* 22). 35 pp. (Dar es Salaam: Government Printer, 1958). Price Shs. 3/50.

Insecticides from Plants. A Review of the Literature, 1941-1953. By M. Jacobsen. *Agric. Handb. U.S. Dep. Agric. No.* 154. 299 pp. (Washington 25, D.C.: Superintendent of Documents, 1958).

World Survey of Pest Control Products. By L. G. Arrington. *Publ. U.S. Dep. Commerce.* 213 pp. (Washington 25, D.C.: Superintendent of Documents, Government Printing Office). Price 60 cents.

A Handbook on the Principles of Plant Quarantine Enforcement for Indonesia. By O. D. Deputy and M. S. Harahap. 165 pp. (*Pemb. Balai Besar Penj. Pert., (Contr. gen. agric. Res. Sta. Bogor*), 1957, No. 146.

Bibliographie der Pflanzenschutz-Literatur. (Bibliography of Plant Protection). 1951. *Publ. Biol. Reichsanst. f. Land-u. Forstwirtschaft*, 1955. 420 pp. (Berlin: Paul Parey, SW68, Lindenstrasse 44-47, West Berlin).

Blood Tests for Users of O.P. Insecticides. By E. F. Edson. *World Crops*, 1958, **10,** No. 2, 49-51. Procedure and field kit for detecting over-exposure to organo-phosphorus insecticides.

Chemical Structure and Activity of Pyrethrin and Allethrin Synergists for Control of the Housefly. By M. Beroza and W. F. Barthel. *J. Agric. Fd Chem.*, 1957, **5,** No. 11, 855-859.

The Relative Susceptibility to Pyrethrum in Oil of *Coleoptera* and *Lepidoptera* infesting Stored Products. By C. J. Lloyd and P. S. Hewlett. *Bull. ent. Res.*, 1958, **49,** Part I, 177-185.

Report of the Pyrethrum Board of Kenya, 1957-1958. 17 pp. (P.O. Box 420, Nakuru: Pyrethrum Board of Kenya, 1958).

LIVESTOCK AND ANIMAL PRODUCTS

Meat. A Review of Production, Trade, Consumption and Prices relating to Beef, Live Cattle, Mutton and Lamb, Live Sheep, Bacon and Hams, Pork, Live Pigs, Canned Meat, Offals, Poultry-Meat. *Publ. Commonw. econ. Comm.* 105 pp. (London: H. M. Stationery Office, 1957). Price 5*s.*

Report, Leather Industries Research Institute, 1-4-57—31-3-58. 43 pp. (Grahamstown, Union S. Africa: Rhodes University College, 1958).

Report, Department of Agriculture, Canada, Health of Animals, for the Year ended March 31*st*, 1956. 33 pp. (Ottawa: Queen's Printer, 1957).

The Indigenous Cattle of the British Dependent Territories in Africa. *Colon. adv. Coun. agric. Anim. Hlth. For., Publ. No.* 5. 186 pp. (London: H. M. Stationery Office, 1957). Price £1 10*s.* 0*d.* net.

Report, East African Veterinary Research Organization, 1956-57. 74 pp. (Nairobi: Government Printer, 1958). Price Sh. 5.

Report of the East African Hides and Leather Bureau for the Years 1956 *and* 1957. 79 pp. (Nairobi: Government Printer, 1958). Price Sh. 7/50.

Report, Veterinary Department, Kenya, 1957. 89 pp. (Nairobi: Government Printer, 1958). Price Sh. 5.

Report of the Veterinary Department, Federation of Nigeria, for the Year 1956-57. 23 pp. (Lagos: Federal Government Printer, 1958). Price 9*d.* net.

A Handbook on Nigerian Hides and Skins. By I. Mann. 53 pp. (Kaduna, N. Region: Government Press and Crown Agents, 1957). Price 9*d.* net.

Report on the Department of Veterinary Services of the Northern Region of Nigeria, 1955-56. 26 pp. (Kaduna: Government Printer, 1958). Price 9*d.* net.

Report on the Veterinary Department of the Western Region of Nigeria for the Year 1955-56. *Sess. Pap. No.* 6 *of* 1958. 13 pp. (Western Region, Nigeria: Government Printer, 1958). Price 9*d.*

Report, Veterinary Department, Nyasaland, 1957. 51 pp. (Zomba: Government Printer, 1958). Price 5*s.*

Report of the Game and Tsetse Control Department, Northern Rhodesia, for the Year 1957. 28 pp. (Lusaka: Government Printer, 1958). Price 2*s.*

Report of the Veterinary Department, Tanganyika, 1957. *Vol. I.* 42 pp. (Dar es Salaam: Government Printer, 1958). Price Shs. 5/50.

Effectiveness of Commercial Papain in Meat Tenderization. By S. Weiner *et al. Food Tech., Champaign*, 1958, **12**, No. 5, 248-252.

Miscellaneous Agricultural Products

The Chemical Industry in Europe. A Study prepared by the Chemical Products Committee in October, 1957. *Publ. O.E.E.C.* 199 pp. (Paris: O.E.E.C., 1957). Price 18*s.*; $3.00; 900 Fr. francs.

The Sugar Detergents. By H. B. Hass. *Mfg Chem.*, 1958, **29**, No. 4, 152-153.

Oils, Oilseeds and Waxes

Vegetable Oils and Oilseeds. A Review of Production, Trade, Utilization and Prices relating to Groundnuts, Cottonseed, Linseed, Soya Beans, Coconut and Oil Palm Products, Olive Oil and Other Oilseeds and Oils. *Publ. Commonw. econ. Comm.*, 1958. 219 pp. (London: H. M. Stationery Office, 1958). Price 5*s.* net.

Annual Review for 1957 *of Oilseeds, Oils, Oilcakes and Other Commodities.* 87 pp. (London: Frank Fehr & Co., Limited, 1958).

The Vegetable Oils Industry, 1956. *Report of Dominion of Canada Bureau of Statistics, Vol.* 2, *Part XVIII.* 10 pp. (Ottawa: Queen's Printer, 1957). Price 25 cents.

Oilseeds in the Second Five Year Plan. By R. Sankaran. *Indian Oilseeds J.*, 1957, **1**, No. 5, 295-297.

Report, Indian Central Oilseeds Committee, 1955-56. 181 pp. (Gandhi Bhavan, Hyderabad: Indian Central Oilseeds Committee). Price Rs. 3/-.

Oilseeds. *Publ. Org. Eur. econ. Co-op.* 333 pp. (Paris: O.E.E.C., 1957). Price 24*s.*; $3.50; 1,200 francs. Review of world production, consumption and trade, with particular reference to groundnuts, copra and coconut oil, oil palm.

Rapport Annuel, Institut de Recherches pour les Huiles et Oléagineux, 1956. 111 pp. (Paris: 16e: Institut de Recherches pour les Huiles et Oléagineux).

Les Transformations de l'Amidon dans les Tissus des Oléagineux. (Starch Transformations in the Tissues of Oil-yielding Plants). By I. N. Svechnikova. *Oléagineux*, 1957, **12**, No. 12, 735-740.

Quelques Renseignements Nouveaux sur la Structure Glycéridique des Corps Gras Naturels. By P. Savary *et al. Rev. franç. Corps gras*, 1958, **5**, No. 10, 493-498.

Report of Coconut Research Board of the Coconut Research Institute, Ceylon, for 1956. *Sess. Pap.* VI—1958. 67 pp. (Colombo: Government Printer, 1958). Price Re. 1.75. Postage 35 cents.

Report, Indian Central Coconut Committee, 1st April, 1956 *to 31st March,* 1957. 67 pp. (Ernakulam—1: Sathiaprakasini Press, 1958).

Copra Processing in Rural Industries. By A. Aten *et al.* 122 pp. *F.A.O. Devel. Pap. No.* 63, 1958. 122 pp. Price $1.50 or 7*s.* 6*d.*

High Quality Copra from Hot-Air Driers. By D. R. A. Eden. *SPC Quart. Bull.*, 1958, **8,** No. 2, 23-25, 62.

Report of the West African Institute for Oil Palm Research, 1956-57. 132 pp. (Benin City, Nigeria: Director, West African Institute for Oil Palm Research, or Crown Agents). Price 2*s.* 6*d.*

The Natural History of Jojoba (*Simmondsia chinensis*) and its Cultural Aspects. By H. S. Gentry. *Econ. Bot.*, 1958, **12,** No. 3, 261-295.

Industrial Raw Materials of Plant Origin. IV. A Survey of *Simmondsia chinensis* (Jojoba). By P. M. Daugherty *et al. Econ. Bot.*, 1958, **12,** No. 3, 296-304.

Antioxygènes pour Savons. By S. Durant. *Rev. franç. Corps gras,* 1958, **5,** No. 6, 320-325.

Papermaking Materials

Report of the Tariff Board, Commonwealth of Australia, on Paper and Paper Products, September 9th, 1957. *No.* 67. 63 pp. (Canberra: Government Printer 1957). Price 3*s.*

Yearbook, Technical Association of the Pulp and Paper Industry, 1958-1959. 541 pp. (New York 17: Technical Association of the Pulp and Paper Industry, 1958).

Pulp and Paper. World Review Number, 1957, **31,** No. 8. 314 pp. (San Francisco 5: Circulation Manager).

The Fractionation of Spruce Wood. By J. A. McPherson. *Acta chem. Scand.*, 1958, **12,** No. 4, 779-780.

The Chemical Composition and Fibre Properties of the *Tamarix articulata* from the Negev. By M. Lewin and A. Reibenbach. *Bull. Res. Counc. Israel,* 1957, **6a,** No. 3-4, 256-270.

Rubber

Report on the Progress of Rubber Technology, 1957, **21.** 134 pp. (Cambridge: W. Heffer & Sons, Ltd.). Price £1 5*s.* 0*d.*

Report, Research Association of British Rubber Manufacturers, 1958. 57 pp. (London: British Rubber Producers' Research Association, 1958).

Report of the Natural Rubber Development Board for 1957. 56 pp. (London: Natural Rubber Development Board, 1958).

Tariff Board's Report on Rubber, 19th August, 1955. *Commonwealth of Australia.* 18 pp. (Canberra: Government Printer, 1957). Price 1*s.* 3*d.*

Soils

Manures and Fertilizers. By H. V. Garner. *Bull. Minist. Agric., Lond., No.* 36. 104 pp. (London: H. M. Stationery Office, 1957). Price 4*s.* 6*d.* net.

Report on the Department of Soil and Land-Use Survey, Ghana, for the Year 1956. 19 pp. (Accra: Government Printer, and Crown Agents, 1958). Price 2*s.* 6*d.*

Report, Soil Conservation Service of New South Wales, for the Year ended 30th June, 1957. *No.* 88. 24 pp. (Sydney: Government Printer, 1958). Price 2*s.*

Soil and Land-Use Surveys, No. 2, British Guiana. The Rupununi Savannahs. By R. F. Loxton *et al. Publ. Regional Research Centre, British Caribbean.* 33 pp. (Trinidad: Imperial College of Tropical Agriculture, 1958). Price 15*s* 0*d.*

Soil and Land-Use Surveys, No. 1, Jamaica. Parish of St. Catherine. *Publ. Regional Research Centre, British Caribbean.* By K. C. Vernon and T. A. Jones. 42 pp. (Trinidad: Imperial College of Tropical Agriculture, 1958). Price 20*s.* 0*d.*

O Valor do Estrume, da Farinha de Ricino, da Farinha de Peixe e do "Composto" nas Adubações das Terras. (Value of Straw, Castor Seed Cake, Fish Meal and "Compost" for manuring the Soil.) By I. Barbosa. *Gaz. Agric Angola*, 1958, **2**, No. 7, 795-798.

Sugar

The South African Sugar Year Book, No. 27. 1956-57 Edition. *Publ. S. Afr. Sug. J.* 269 pp. (Durban, P.O. Box 1209: S. African Sugar Journal). Price 10*s.* post free. A reference book and guide to the sugar industry of S. Africa.

Proceedings, South African Sugar Technologists' Association, Durban, 25th-29th March, 1957. 149 pp. (Mount Edgecombe, Natal: South African Sugar Association Experiment Station). Price £1 1*s.* 0*d.* Non-members £1 10*s.* 0*d.*

Indian Sugar Industry (1956-57 *Annual*). *Vol.* 21. 350 pp. (Bombay: Gandhi & Co., 1958). Price Rs. 6*s.*; by V.P.P. Rs. 7*s.*

Sugar Cane Selection Experiments. I. Bunch Planting. By J. C. Skinner. *Tech. Commun. Bur. Sug. Exp. Stas. Qd*, 1957, No. 1. 29 pp. (Brisbane: Director, Sugar Experiment Stations Board, 1957).

Report, Bureau of Sugar Experiment Stations, Queensland, 1957. 102 pp. (Brisbane: Bureau of Sugar Experiment Stations, 1957).

Report, Sugar Cane Research Station, Mauritius, 1957. 100 pp. (Réduit: Mauritius Sugar Industry Research Institute).

Sugar Bulletin, Department of Agriculture, British Guiana, No. 26. 94 pp. (Georgetown: The "Daily Chronicle" Ltd., 1958).

The Jamaica Association of Sugar Technologists Journal. Proceedings of the Association for the Year, 1955. *Vol. XVIII.* 54 pp. (Mandeville P/O: Sugar Research Dep., 1956). Price 30*s.* or $4.50. Symposium of articles on cultivation and utilization of sugarcane.

Report, Hawaiian Sugar Planters' Association Experiment Station, 1957. 80 pp. (Honolulu: Experiment Station Committee).

United Nations Sugar Conference, 1956. Summary of Proceedings. *Publ. U.N.* E/Conf. 22/7. 74 pp. (London: H. M. Stationery Office, 1957. Sales No. II.D.2). Price $U.S. 0.80; 5/6 stg.; Sw. fr. 3.50.

Timbers

The Strength Properties of Some Uganda Timbers. By C. H. Tack. *Bull. Uganda For. Dep., No.* 5. 23 pp. (Entebbe: Government Printer, 1958).

The Principal Timber Trees of the Windward Islands. By H. Fraser. *Development and Welfare in the West Indies, Bull. No.* 35. 32 pp. (Grenada: Conservator of Forests, 1957).

Economic Botany of the Cycads. By J. W. Thieret. *Econ. Bot.*, 1958, **12**, No. 1, 3-41.

Tobacco

Report of the Government Tobacco Warehouse, Mauritius, Year ended 30th June, 1957. 31 pp. (Port-Louis: Tobacco Board, 1957).

Weeds and Weedicides

Analysing New Herbicides and Insecticides. By K. Gardner. *Chem. Prod.*, 1957, **20**, No. 5, 187-190.

Proceedings of the Eleventh Meeting, Eastern Section, National Weed Committee, Western Ontario Agricultural School, Ridgetown, Ontario, October 22nd, 23rd, 24th, 1957. 108 pp. (Ottawa: Secretary, National Weed Committee, Botany Laboratory, Science Service, Department of Agricultulture, 1958).

Proceedings of the Fourteenth Annual Meeting, North Central Weed Control Conference, December 10th-12th, 1957, *Des Moines, Iowa.* 81 pp. (P.O. Box 104, State Capitol, Lincoln, Nebraska: Secretary-Treasurer, North Central Weed Control Conference, Inc.). Price $2.00 .

Proceedings of the Eleventh Annual Meeting of the Southern Weed Conference, Memphis, Tennessee, January 13th, 14th, 15th, 1958. 122 pp. (Abstracts of papers can be obtained from business manager of *Weeds*).

Proceedings, Sixteenth Western Weed Control Conference, Spokane, Washington, March 18th-20th, 1958. 132 pp. (Bozeman, Montana: Secretary-Treasurer, Western Weed Control Conference, 1958). Price $2.00.

Proceedings of the Eleventh Meeting, Western Section, National Weed Committee, Victoria B.C., November 25th, 26th, 1957. 76 pp. (Ottawa: Secretary, National Weed Committee, Department of Agriculture, 1958).

Research Progress Report, Research Committee, Western Weed Control Conference, Washington, March 18th, 19th and *20th,* 1958. 108 pp. (Bozeman, Montana: Secretary-Treasurer, Western Weed Control Conference, 1958). Price $2.00.

Symposium on *Eichhornia crassipes,* Leopoldville, 1957. *Publ. No. 27, Scientific Council for Africa South of the Sahara.* 33 pp. (London: Joint Secretariat, C.C.T.A. /C.S.A.).

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